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TECHNICAL NOTE

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Land Management

U.S. DEPARTMENT OF AGRICULTURE
U.S. Forest Service

WILD, FREE-ROAMING BURROS - STATUS OF PRESENT KNOWLEDGE

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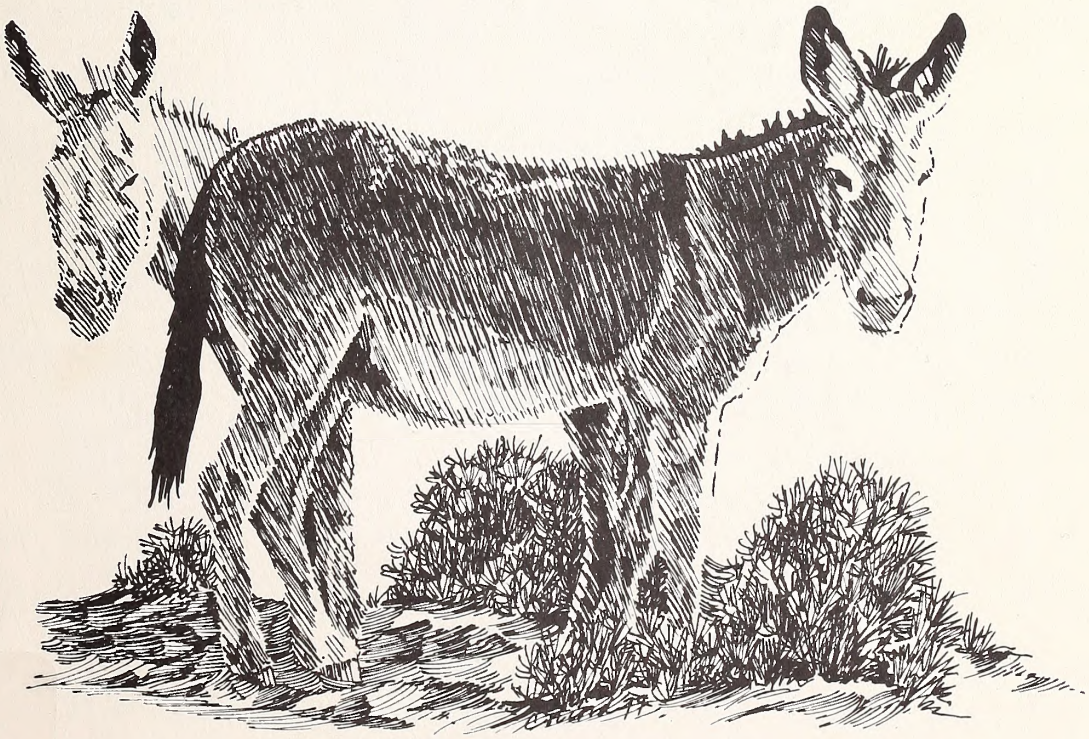

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Introduction

The purpose of this report is to provide personnel of the U. S. Forest Service and U. S. Bureau of Land Management with a literature review and summary of available information on wild burros.

Little scientific and recorded factual information on America's wild burros exists. Klingel (1972), who has spent many years studying the wild Equidae of Africa, claims that except for social organization, all members of the genus Equus are greatly similar. As a result, many portions of this technical note have been based on data from domestic horses or from other members of the Equidae, and its applicability to America's wild burros will have to stand the test of future research.

Few people know very much about wild burros. Certain individuals such as ranchers and others who have been around burros most of their lives often possess a remarkable store of knowledge on burro habits and general ecology. We include much anecdotal information which cannot be verified or documented.

Problems in managing wild burros remain extremely complicated. To manage burros as truly wild animals, with little interference from man, entails many hazards and has become almost an impossibility under the increasing pressures for various land uses.

We are not dealing with a homogeneous population of wild animals. At one extreme are those animals that have lived in the wild for many generations and which are capable of surviving under the harshest of conditions. Then there are animals only a step or two away from domestication that have not yet adapted to their environment. Management efforts in relation to game animals or domesticated livestock remain hamstrung by lack of basic biological data and may be further restricted by special interest groups or the emotional issues involved.

Origin and History of Wild and Feral Horse and Burro

Present-day equids have descended from a small, four-toed, rodent-like creature known as eohippus, the dawn horse, whose correct generic name is Hyracotherium. This name arose because early scientists did not recognize that the fossil remains of a small animal discovered near Suffolk, England in 1838 was related to horses. They instead compared its remains to the hyraxes, similar in size and external appearance to rodents and lagomorphs, which the fossil closely resembled. When investigators discovered more of these fossils in North America at a later date, the principles of evolution had become well established and they were recognized as horse ancestors. Charles Marsh, of Yale

University, gave these fossils the euphonious name, Eohippus, but since Hyracotherium is much the older of the two terms, under the rules of zoological nomenclature it is the correct one to use.

Eohippus lived at the same time in both Europe and North America, appearing in both places at the very beginning of the Eocene. No direct ancestors of eohippus have been found on either continent.

The several species of eohippus varied greatly in size, from not much over 10 inches in height at the shoulder to about 20 inches.

Four toes appear on the front foot of eohippus, each ending in a separate small hoof. The hind foot had only three functional toes. The animal was already distinctly herbivorous with teeth structured for browsing rather than grazing (Simpson, 1951).

In the beginning of the Cenozoic Era of geologic time (70 to 75 million years ago) the British Isles and North America were attached as part of the supercontinent of Laurasia, which also included Greenland and Europe north of the Alps and east to the Himalayas.

During the long period when Laurasia was separating, animals were able to migrate back and forth on the land bridges that still connected Europe and North America. During this time eohippus arose and occupied both North America and Europe. Not long after this the continents separated and migration ceased. In Europe, for an unknown reason, eohippus became extinct. In North America through a period of about fifty million years eohippus evolved into Mercyhippus, an animal with high crowned teeth that permitted it to graze rather than browse. It was a larger animal, about the size of a small pony of today.

After Mercyhippus, a gap in the fossil records stretches from about six million years ago to about 600,000 B.C. During this period Mercyhippus evolved into Pliohippus, and it is from Pliohippus that the genus Equus evolved. Sometime near the beginning of the Pleistocene all of the members of the Equidae belonged to a single interbreeding group. As the various populations spread over Asia, Europe and Africa certain groups became geographically separated, ceased to breed with each other and eventually became separate species. Such scanty records as exist came mostly from Eurasia. Since a land bridge connected Alaska and Siberia during the Ice Age it is probable that Equus caballus evolved in Asia from some of its ancestors that migrated from North America.

About 600,000 B.C. changes in conditions brought the early equids back to the American West. Their fossil remains, found in many different places, date from this period up to about 7000 B.C., when they apparently vanished along with several other species of large grazing animals.

There was no such mass extinction of species in Europe. As the ice sheet melted, Europe warmed and the forests encroached on the grasslands, forcing grazing herds eastward onto the steppes of southern Russia and western Asia. Tribes of early hunters followed the herds, became semi-nomadic and by 5000 B.C. used hunting dogs and had domesticated the Onager (Asian wild ass) and reindeer (Haines, 1971; Ryden, 1970; Howard, 1965; Simpson, 1951). Appendix I depicts important features of equine evolution.

Domestication of the burro. Men tamed the horse for war and the hunt; women tamed the burro for peaceful pursuits. It was of convenient height and easy to load, possessed a serene disposition and an easy gait. The burro first became a pet and later a burden bearer (Brookshier, 1974).

It is uncertain whether the ass was first domesticated by the Egyptians or the Libyans, but domestication took place probably in the third millennium B.C. From there it was introduced into Syria and Palestine and, for a period of almost 4000 years, largely confined to the Mediterranean region. Men first used burros as beasts of burden and later as draft animals throughout North Africa, Mediterranean Europe and Southwestern Asia (Haines, 1972).

Uncertainty exists as to just when the burro arrived in Europe. Some scholars believe that burros lived in Europe during Neolithic times. Spain and Portugal have long been the home of the burro, and there are claims that burros were indigenous to Catalonia in northeastern Spain. It lived in Spain during Roman times, and when the Moors invaded they brought additional burros from North Africa. It may have moved northward in Europe during the third and fourth centuries, but little information exists about burros during the decline of the Roman Empire and during the Middle Ages (Brookshier, 1974).

The burro became important throughout Europe as well as England, Scotland and Ireland for transportation, as a pack animal, in agricultural production and in folklore. In France burro milk and flesh were prized as food. During the Middle Ages men used burro manure to treat diseases of the eye, and as a cure for gout, burro hooves were bound to the patients' lower extremities. The blood was said to have prophetic powers and was used in rituals to foretell coming events.

It is believed that the domesticated burro of Persia worked its way north at a very early date into lands along the Persian Gulf and the ass that later appeared in central Asia descended from the African species. Soviet paleontologists concluded that the African ass appeared in west-central Asia some time between 200 B.C. and A.D. 300. A Greek geographer wrote nearly two thousand years ago that horses were scarce but that many burros lived on the farms in Iran, Persia and India.

The mainland of China has more burros than any other country in the world, but ancient writers seldom mentioned them. They were first referred to in a Chinese proverb by a poet around 330 B.C. who left little doubt that the burro was well known and important: "A wife can be bought for five dollars; an ass costs fifteen." The burro was part of the traffic on the east-west caravan route across Turkistan and along the silk road that led from eastern China to India and Turkistan. Burros were transported from the mainland of China to Japan and Korea prior to the twelfth century.

The burro, a familiar figure in Greece from ancient times, probably came from Asia Minor. It remained uncommon in the colder regions north and east of Greece, yet evidence exists that burros had been living for centuries in Asiatic Turkey.

Records of burro history are more plentiful in Egypt than in other countries but there is little doubt that burros played an important role in other parts of Africa.

The Libyans west of the Nile had large herds of burros prior to the Egyptian dynasties which began about 3200 B.C. Burros were first used as dairy animals, then as work stock and as food. Burro milk was used as a cosmetic. Later burros came into use along the trade routes in the Nile Valley, the Sudan, Nubia, Ethiopia and across the Sinai Desert to the Middle East. Since the ox was not a good desert traveler and the horse did not arrive until much later the burro became the primary means of transport. The mule, due to crossbreeding, never became popular in countries ruled by Muslim law.

Pack trains of burros were moving between Arabia and Egypt as early as 3000 B.C. and by 1000 B.C. burros appeared in the Mediterranean islands of Cypress and Crete as well as in Turkey and Sicily.

Romans used burros as pack animals, in agriculture and as food. Like other early cultures the Romans made cheese from the milk, sausage from the meat, used the blood, sweat and urine as medicine, sacrificed burros in rituals and matched the wild Onager against all comers in the Roman games.

The burro went west with the Spanish conquistadors to the New World; they remained in the West Indies several years before they set foot on the mainland. Burros soon appeared in northeastern Brazil and in Mexico and were imported into Venezuela perhaps before 1535, and soon spread to Argentina and Peru. The trade route from Vera Cruz to Mexico City, established by Cortes in 1522, was important for three centuries; pack trains of burros and mules transported as much as fifty thousand tons a year over this route until the advent of the railroad in 1873.

The first burros to enter the United States probably belonged to the Spanish colonizer Juan de Oñate who crossed the border from Mexico in about 1599 near present-day El Paso, Texas. A few years after Oñate's arrival pack trains of burros were moving between Chihuahua, Mexico and the Rio Grande Valley in New Mexico. From the Rio Grande basin they quickly spread to other parts of the West, playing a diversified role in the mining economy that spread from New Mexico through the western United States and into Canada and Alaska from the eighteenth to the early twentieth century. Burros also moved eastward along the Santa Fe Trail to Missouri (Brookshier, 1974).

During the last half of the nineteenth and early part of the twentieth centuries the burro arrived in Australia and later spread to New Zealand and Tasmania.

Scholars presume that mating between male donkeys and female horses originated about 2000 B.C. among the Edomites and Hosites of Asia Minor. Crossing a male burro with a mare produces a hybrid mule, which attained the size of the horse but served much better as pack and work animals. Crossing a stallion with a female burro produced the hinny, an animal that never achieved popularity as a work and pack animal. Both animals, the mule and the hinny, are usually sterile (Brookshier, 1974).

The crossbreeding of asses and horses to obtain mules became a profitable enterprise at some of the stud farms in New Spain, and mules appeared in Spanish settlements in Mexico before 1625. Indian tribes in New Mexico and the Apache-Navaho tribes bred mules for pack trains and for meat. By 1750 both the Comanches and the Pawnees were breeding mules. California also became a center for mule production. In 1833 California missions owned 62,500 horses, mules and burros (Howard, 1965). The large jacks and jennets that later made Kentucky, Tennessee and Missouri famous as mule breeding states were developed in Italy, France, Malta and Spain. These animals entered the United States from the Atlantic seaboard states.

In 1785 the King of Spain sent George Washington two jacks and two jennies. One of the males died; the other, named Royal Gift, sired many mules. Later Spain advised Washington that it

had a surplus of jacks and jennies and that could be delivered at less than the cost of a good draft horse. Forty years after Royal Gift's arrival at Mount Vernon men lauded the mule as a national resource and as an invaluable servant.

A popular turn-of-the-century writer on western subjects wrote that the burro was the cornerstone of history and that two-thirds of the New World would not have been civilized without it (Brookshier, 1974).

It is unlikely that large numbers of feral burros existed until some point in the nineteenth century. Before this, burros were valuable property. Prospectors, miners, sheepherders, and other travelers depended upon burros for pack animals because they were able to pack heavy loads for long distances, were surefooted and could survive on scanty desert vegetation. With the advent of better roads which permitted faster means of transportation and the decline of the mining boom, many burros were turned out on the open range. Others were abandoned when their owners died or they escaped through loose confinement. Due to their high rate of reproduction and the fact that they were turned loose in so many different areas, feral burros became widely distributed over most of the western states by the last quarter of the 19th century (McKnight, 1958).

Species Description

Generally, investigators agree that the present-day burro (*Equus asinus*) originated from African wild asses. Controversy exists, however, as to which species of wild asses constituted the parent stock. Haines (1971) states that in early times three geographical races of African wild asses occurred, one in north Africa, one in northwest Africa and another in Somalia. The domesticated asses originated from the two north African races. Simpson (1952) merely states that the ancestors and relatives of our domestic donkeys came from northern and northeastern Africa. Moehlman (1974) gives the source as northeast Africa and Goodwin (1954) says that the Somali donkey (*Equus asinus somalicus*) is probably the stock from which present-day burros derived. Brookshier (1974) says that the present-day burro has all the characteristics of the Nubian wild ass (*Equus asinus africanus*).

In Roman times at least three local races of true asses of African origin existed. One of these, *Asinus atlanticus*, became extinct before it could be seen by a modern zoologist. It had a well-developed shoulder stripe, strongly marked limbs, with ears somewhat shorter than its east African cousins. The geographic distribution was generally confined to the Atlas Mountains (Antonius, 1937).

Equus asinus has several common names: the ass, the donkey, and the burro are the most popular. In Colorado men often referred to it as the Rocky Mountain canary, and in Arizona as the desert canary or desert contralto. The term burro, which is of Spanish origin, is used most often in the western hemisphere.

The International Union for Conservation of Nature and Natural Resources (IUCN) describes the Nubian and Somali asses in its publication, The Red Data Book.

The Nubian wild ass (Equus asinus africanus) has become extinct in its former range in Nubia. Although it has been reported from other areas, there is controversy as to whether these are wild or feral animals. The upper parts are greyish-fawn as is the muzzle and a ring around the eye. The underparts consist of white to grey, extending down the legs. Some grey appears on the front of the legs; dark spots occur on each side of the fetlocks, with a chestnut patch on the inner side of the lower forelegs. The mane is short, upright, and dark brown or black. The narrow dorsal stripe continues as a thin line well onto the tail. The two branches of the shoulder stripe are about 5-6 inches in length. The ears are tipped with black. The height of a measured male was 55 to 56 inches.

Until recent times this animal spread over the mountainous semi-desert areas of Nubia and the eastern Sudan from the Nile to the Red Sea.

The gestation period extends from 11 to 12 months, and a single young is normally born. Mature mares usually breed only in alternate years, and have a life span estimated at 25 to 30 years.

The Somali wild ass (Equus asinus somalicus) presently faces extinction; only a few hundred animals still persist in Ethiopia. This species differs from E. a. africanus by having a generally paler and more greyish color, with the cross-stripe over the shoulders absent. Numerous black markings occur on the legs, and the dorsal line appears only faintly.

Once widely distributed, the animal only survives in any significant numbers in central Danakil in Ethiopia, and is extremely rare in Somalia.

The gestation period is a full year, and the mature females normally bear a single foal in alternate years.

The 1933 London Convention granted legal protection to the Nubian Ass, and it is legally protected in the Sudan also. The Somali ass is protected by law in Somalia. The International Union for Conservation of Nature and Natural Resources (IUCN)

lists both species as endangered in its publication, The Red Data Book (Brookshier, 1974; Moehlman, 1974).

The Somali wild ass stands about four feet, six inches at the shoulder, and has large long ears and small narrow feet. The general body color consists of grey with white underparts and a white patch around the eye. A black stripe runs down the back and another runs across the shoulders (Goodwin, 1954).

The domesticated African and Asiatic species of asses came together at the eastern end of the Mediterranean. The asses that traveled the trade routes from Damascus consisted of crosses between African asses, Nubian asses, and Onagers. Crossbreeding occurred as early as 3000 B.C. wherever tradesmen from Syria, Egypt and Israel met and traded burros. The Nubian ass may have been crossed with the Somali ass; offspring were further crossed with two domesticated species of Asiatic asses, E. hemionus hemihippus and E. hemionus onagra. Despite this mixing of species, the characteristics of the African ass, including the long ears, loud bray and transverse shoulder stripe remained evident everywhere (Brookshier, 1974).

The asses are characterized by their long, deep-set eyes, coarse wiry manes, small feet, absence of forelocks and tails that possess long hair only at the tip. The coat is thick and greyish in winter and a lighter, almost reddish brown in summer (Walker, 1964).

Disagreement exists as to the classification of the Asiatic asses. Some scientists refer to them as "half-asses" due to their apparent intermediacy between true horses and true asses. The Zoological Society of London lists the following known species of asses:

Mongolian wild ass (Equus hemionus hemionus): still fairly common in one area in central Mongolia, but considered very rare in China.

Persian wild ass or Onager (Equus hemionus onager): extremely rare in Persia, but fairly common in the Badkhyz Reserve in the U.S.S.R.

Indian wild ass (Equus hemionus khur): occurs only in the Little Rann of Kutch on the Indo-Pakistan border. In 1962 it was estimated to number 870. Its numbers have certainly decreased since then.

Tibetan wild ass or kiang (Equus hemionus kiang): found on the Tibetan plateau and in parts of Nepal, Sikkim, Ladak and Chinghai. Rare, but not endangered, according to the Chinese.

Syrian wild ass (Equus hemionus hemippus): thought to be extinct.

Nubian wild ass (Equus asinus africanus): Red Sea Hills south of Suakin and Eritrean Border as far south as Atbera River. Very rare if not extinct.

Somali wild ass (Equus asinus somalicus): several hundred persist in Ethiopia, with possibly a few scattered herds in Somalia and Sudan.

Differences between the horse, zebras and the asses include coloration, instincts, habits, personality traits, and social organization. In the wild state, they do not mix and seldom, if ever, crossbreed (Brookshier, 1974).

Colors. The colors of burros vary and may consist of black, brown, white, pinto, or piebald; however, the underside, the muzzle and the area encircling the eyes appears universally white or oyster among all breeds. White burros have special significance in some areas. In ancient times men used them at the sacrificial altar and as mounts for nobility and clergy. In certain areas of the Middle East only white burros occur (Brookshier, 1974). Moehlman (1974) reported colors of the burros of Death Valley National Monument as black, brown-black, grey, roan-grey, paint and bold-faced. The brown-black occur together because most of these animals possess a brown winter coat which sheds to black in the summer. This also occurs in the roan-grey category. Young animals have brown hair as foals which later sheds to roan-grey. Grey animals have shoulder stripes and occasionally leg stripes.

Size. Domestic burros exist in many sizes and weights. An average burro stands about 44 inches tall. The miniature Mediterranean donkey averages 32 to 37 inches in height and weighs about 150 pounds (Brookshier, 1974). Goodwin (1954) describes the burro as standing about four feet, six inches at the shoulder. Walker (1964) lists the length of the head and body as 2 to 2.2 meters, the height 0.9 to 1.5 meters, the length of the tail 42.5 to 49 centimeters, and the weight about 460 kilograms. Yousef et al (1972) reports the weights of E. asinus used in his study as 244 and 263 kilograms respectively. Maloiy (1972) listed the average body weights of the Somali donkeys that he studied. Males averaged 129 to 180 kilograms, females, 156 to 160 kilograms. Ohmart (1974) compared body measurements between male and female feral burros. Thirteen females and nineteen males, all over one year of age, showed no significant differences between sexes in animals from California and Arizona. The means of all measurements indicate a total

length of about 235 centimeters, a shoulder height of about 122 centimeters, tail length near 32 centimeters, and heart girth of about 130 centimeters.

Lumbar vertebrae. Brookshier (1974) states that the burro has five lumbar vertebrae, one less than most horses. Stecher (1962) studied the lateral joints in the caudal lumbar region of the equidae. He examined the skeletal remains of 245 equids of nine species obtained from various sources, and classified animals according to whether they had five or six lumbar vertebrae. Skeletal specimens included the domestic horse, the Arabian horse, the shetland pony, Przewalski's horse, the hybrid mule, two species of asses and two of zebras. Eighteen skeletons of asses were examined. Fifteen of these had five lumbar vertebrae, two had six, and one, for an unexplained reason, was not counted.

Lifespan. Legend has it that the burro never dies and that no one has ever seen a burro dead from natural causes. Fairly authentic records show that a few burros have lived to be forty or fifty years old. In general they live longer than the horse, and the females live longer than males (Brookshier, 1974).

Age determination in members of the Equidae. The age of members of the Equidae is generally determined by the amount of wear of the teeth. Naturally, any equid that has to forage for his food in a harsh environment of stony, sandy soil will show much greater dental wear, and true age will be more difficult to determine (Bone, 1964).

The mature male has forty teeth; a young animal, male or female, has twenty-four teeth. The mature female lacks canines and therefore has thirty-six teeth. In animals up to five years of age, investigators note the numbers of permanent and milk teeth. From six to twelve years, they estimate age by the number of cups or indentations in the incisor teeth. After twelve years, age may be judged by the cross section and slant of the incisors. Learning to determine age in horses is a matter of practical experience. When an animal exceeds twelve years even the most experienced workers have difficulty in determining accurate age (Ensminger, 1951).

Locomotion. Among the Equidae the Asian ass (E. hemionus) is considered to be the swiftest, with the African E. asinus and the zebra the slowest. The Asian ass has reached speeds of 40 miles per hour for short distances and 30 miles per hour for a distance of 16 miles (Moehlman, 1974).

The burro, like other equids, has three primary gaits: the walk, the trot, and the gallop. Only since the development of the high-speed camera has man learned accurately how the equids coordinate their four legs during locomotion (Simpson, 1951; Tricker and Tricker, 1967; Moehlman, 1974).

The walk has a four-beat cadence with the succession of footfalls being left-fore, right-hind, right-fore, left-hind. The body is alternately supported on three and on two legs. The trot, a faster gait, consists of a two-beat cadence where the diagonal legs move together so that the sequence of feet striking the ground is left-fore, right-hind followed by right-fore, left-hind. Twice in each stride occurs an interval where all four feet are off the ground.

The gallop is the fastest gait and differs from the others in not being symmetrical on the two sides. It may be led either on one side or the other. The three-beat cadence consists of a broken rhythm that occurs as beat, pause, beat, quick double beat, beat, pause, etc. The pause represents the short period when all four feet are off the ground, which occurs only once in each stride. The sequence of footfall for the left lead is left-fore, right-hind, left-hind and right-fore, the latter two almost together with the hind foot slightly ahead. The right-hind foot is lifted almost immediately as the left hind foot comes down and before the right forefoot strikes. Normally, at no time are three of the animal's feet on the ground. The right lead is a mirror image of the left lead. In an extended gallop there may be four beats as opposed hind and forefeet strike at perceptible intervals, however, the break after the placing of the lead foot still distinguishes the cadence (Simpson, 1951; Tricker and Tricker, 1967).

Few of the Equidae jump regularly unless they are taught. This may be due in part to their impaired close-range vision, which prevents them from judging the correct take-off distances (Hafez et al, 1969).

Drawings from a motion picture strip depict leg positions of the Equidae while walking, trotting and galloping. (See Appendix 2.)

Moehlman (1974) noted that the feral burros in Death Valley seldom galloped. The only extended gallops observed occurred when a territorial male was chasing a non-territorial male away from an estrous female. Foals often galloped for short distances during play.

The horse possesses an almost rigid spine; the thigh is coupled to the body with strong muscles and ligaments, and so the thigh

bone moves in a limited arc. Most of the advancement of the hind limb of the horse when galloping occurs through the stifle joint because the accessory ligament unites the lower front portion of the pelvis to the head of the femur and limits femur movement. The horse can lash out behind with his hooves quite well but only a few horses can kick forward (like a cow) with any efficiency. However, asses, mules and zebras use the forward kick as one of their main defensive weapons (Smythe, 1967).

Population Characteristics

Properties of a collective group of organisms or populations include density, birth rate, death rate, age distribution, biotic potential, dispersion and growth form. Genetic characteristics such as adaptiveness, reproductive fitness, and persistence (leaving descendants over long periods of time) also directly relate to populations (Odum, 1971).

Three major age groups occur in any population: the pre-reproductive, the reproductive and the post-reproductive. In a rapidly growing population, growth may be exponential due to a high birth rate; each successive generation will be more numerous. This results graphically in a pyramid age structure. The graphic representation of a stable population forms a bell-shaped curve. The pre-reproductive and reproductive age groups are fairly equal in size and the post-reproductive age group remains small. If the birth rate drastically lowers, the reproductive and post-reproductive age groups increase proportionally, resulting in an urn-shaped graph representative of a declining population (Boughey, 1968).

Odum (1971) described characteristics of populations in regard to age structure. An expanding population contains a large proportion of young animals; a stationary population shows a more even distribution of age classes; a declining population displays a large proportion of old individuals.

The population density of wild burros, like that of any other animals, must not exceed the carrying capacity of the available habitat. Other than this general observation and the limited data that Hall (1972) and Feist (1971) collected on the Pryor Mountain horses, there is no scientific information available on optimum population levels, the results of overcrowding, competition or the effects of a degrading habitat. However, evidence exists that wild burro densities could be reduced, through improper management and control, to a level that might lead to their extinction either locally or nationally.

The critical size of a population varies from species to species. Once the population density of a particular species drops below this level, the species is doomed to extinction regardless of efforts to save it. Prime examples include the passenger pigeon, which died out completely even though hunting had ceased and there were still several thousand remaining birds scattered over North America, and the Heath hen, which, although rigorously protected after the population level had become small, suffered the same fate.

Since their social life plays an important part in locating feeding areas, raising young and defending against enemies, gregarious animals such as the ungulates are particularly susceptible to the danger of extinction when their density reaches a certain level.

A number of factors may determine this critical population size. Three of the more important of these are: (1) Males fail to find females due to low density. (2) Courtship behavior is inhibited by local low population density. (3) The remaining population is too small to resist predators and competitors (Ziswiler, 1967). Erhenfeld (1972) adds another factor: the population size may become too small to enable reproduction to compensate for losses from disease, climatic conditions, or natural disasters.

Both Feist (1971) and Hall (1972) reported on population characteristics of the Pryor Mountain horses. Their data indicates that the population structure of these horses is unsound.

Hall spent an entire year during 1971 and 1972 in the field. He gathered population data through personal observation and by aging and sexing 124 captured or immobilized animals, and augmented the collection of information on behavior and distribution with the aid of a spotting scope. Feist gathered his data through personal observation and the use of binoculars during the period from May 1 to November 1, 1972. Hall reported large gaps in the age structure due to the absence of young animals, and estimated the population to consist of about 60% males to 40% females. He concluded that the unbalanced age structure and the preponderance of males to females resulted primarily from poor nutrition. The younger animals starved or became so weak that they were susceptible to disease. Females, in poor condition from lack of food, suffered added stress during pregnancy and lactation. He predicted disaster for the herd if these conditions persisted for five or more years.

Feist, on the other hand, estimated that the sex ratio for the entire herd and for mature animals was nearly balanced. Imbalance occurred, however, in the immature, yearling and foal

classes. In immatures and yearlings, males outnumbered females; in the latter the reverse was true. Feist admitted his sample size for these three age classes was too small to determine trends. His data showed that foals comprised 13%, yearlings 11%, immature about 18%, and mature 58% of the total population. Thirty-five dead horses were found during the study of which 14 were male, 14 female; sex was undetermined in the remainder. High mortality occurred among horses less than one year old. Causes of death included jaw and skull injury from fighting, abnormal teeth wear, foals becoming lost or orphaned, leg injuries, and starvation.

The Susanville District of the Bureau of Land Management in California conducted two aerial inventories of horses and burros. Their latest inventory, of August 1973, indicated that over 18% of the entire population consists of young animals. However, various age classes within the young were not identified.

Population Status and Trend

The available population data on public lands administered by the U. S. Bureau of Land Management and by the U. S. Forest Service appear by state. Some overlap in figures between Forest Service and BLM lands may exist. Population data from state, private and other lands is not available. See map.

Bureau of Land Management Feral Burro Inventory Data
Estimates of Population

State	Number of Burros	Number of Burros Claimed
Arizona	2134	--
California	2147	--
Colorado	--	--
Idaho	9	--
Montana	--	--
New Mexico	104	64
Nevada	691	50
Oregon	20	--
Utah	78**	--
Wyoming	--	--
Total	5183*	114

* Includes animals claimed; proof of ownership still must be determined under Section 5 of the Wild Horse and Burro Act of 1971.

** Includes 8 mules

Above figures include the number of feral burros inventoried as of 1 May 1975.

U. S. Forest Service Feral Burro Inventory Data
Estimates of Population

State	Nov. 1971 Estimate	Jan. 1974 Inventory	Jan. 1975 Inventory
Arizona	30	36	32
California	206	209	256
Colorado	-	-	-
Idaho	-	6	7
Montana	-	-	-
Nevada	14	13	13
New Mexico	8-10	5	5
Oregon	-	-	-
Utah	1	3	-
Wyoming	-	-	-
Total	261	272	313

Up to 75 percent of burros inventoried on the National Forests also utilize BLM lands and may be duplicated in their inventory figures.

Population figures from U. S. Forest Service lands in 1974 and 1975 indicate that feral burro populations are increasing there; no projection can be made from the BLM figures.

Reproduction

Sexual behavior in females. The gestation period accepted as standard in burros lasts twelve months but can vary from eleven to thirteen months (Hutchins *et al*, 1973). The gestation period of the jenny runs about 374 days (Brookshier, 1974). The average gestation period of zoo animals (*E. asinus*) is 365 days (Moehlman, 1974).

A domestic jenny usually comes into heat for the first time during her second spring or summer. Jennies begin reproducing at about three years of age and may continue for thirty years (Hutchins *et al*, 1973; Brookshier, 1974). Moehlman (1974) noted the occurrence of the first heat period in wild burros at about eighteen months. Foaling, however, seldom occurred in feral jennies prior to four years of age. The average breeding life of Grants zebra (*E. burchelli bohmi*) and Grevy's zebra (*E. grevyi*) starts at puberty, but conception may not occur until after a number of estrous cycles (King, 1965). Tyler (1972) reported that most New Forest, semi-wild, pony

mares foaled for the first time when three or four years old, but some waited until they were five years old. Very few of the 141 mares that were three years old or more foaled in each of the three years of study. Foaling in alternate years was common; so were abortions during the late autumn, winter, and early spring.

Estrous cycles have been described for the horse (E. caballus) but little data exists on the burro. The most distinguishing feature of the estrous cycle of equids consists of the long period of estrous within the cycle (Berliner, 1969). Short and Welch (1965) stated that the irregularity of the estrous cycle and an estrous period which varies from five to 21 days contribute to breeding problems in burros. The estrous periods of domestic mares recur at approximate 21-day intervals with a range of 18 to 27 days. The length of the estrous period varies from five to eight days but may be longer in early spring. Postpartum estrous usually occurs 7 to 11 days after foaling (Ensminger, 1951). Moehlman (1974) stated that peak conception and natality in feral burros occurred during the months of May, June and July. The longest estrous she noted lasted eight days. She observed postpartum estrous in only one female; this occurred seven days after foaling.

Moehlman concluded from her studies that feral burros were polyestrous: they could breed at more than one season of the year. Eckstein and Zuckerman (1956) reported that wild members of the Equidae are monoestrous. Berliner (1959) states that when a female equid shows mating desire she is probably able to reproduce. Some members of the family can do this and they are truly polyestrous. For the most part, however, reproduction occurs in a more restricted period, even though females go through heat cycles most of the year. The appearance of the first heat cycle does not always coincide with the true breeding season. Therefore, from the standpoint of estrous behavior, the equidae can be classified as polyestrous, but from the standpoint of reproductive performance they are primarily monoestrous. Berliner (1959) postulates that the polyestrous trait has become an acquired characteristic brought on by domestication and breed improvement.

Nishikawa et al (1950) found the breeding season of female ass in Japan to take place between April and December. Berliner (1959) reports that the breeding season in south Africa occurs from October to April. Jennets in Mississippi are polyestrous, but display seasonal variations. Conception rates were very low in the spring but improved in the summer and were maintained well into the fall. Both Grant's and Grevy's zebra breed throughout the year, and peak foaling in Grant's zebra occurs from January to March (King, 1965).

Clegg and Ganong (1969) cite many observations which indicate that domestic mares will breed at any season if they are well fed. When mares are maintained on grass they frequently show an estrous during the winter; nutritional factors may be partly responsible. Since the mare breeds predominantly in spring, she might be expected to respond to increasing rather than decreasing day length. Burkhardt (1947) studied the influence of light on the reproductive activity of domestic mares. He divided anestrous mares into four groups. One group received artificial illumination to increase day length. Another group was exposed to ultraviolet light applied to the flank and belly. The mares in this latter group had their eyes hooded. Estrous appeared in the group receiving extended day length about 30 days earlier than in the control. The estrous cycle of those receiving light on the flank and belly was normal. Burkhardt therefore suggested that since irradiation of the ovaries did not alter the estrous cycle, the receptor organ was probably the eye. Nishikawa et al (1954) exposed anestrous mares to increased day length from mid-November until the end of February. The investigators concluded that light was a factor, but not the sole one, controlling reproductive activity in mares. King (1965) states that both Grant's and Grevy's zebra breed throughout the year with peak foaling occurring from January to March. He concludes that variations in seasonal breeding activity near the equator must relate to environmental factors other than light.

Jennets show receptivity to the male by assuming a stance similar to lordosis, and fold their ears back on the neck, making gnashing motions with their jaws. Mounting of other females often occurs in jennets but rarely in mares (Berliner, 1959). Moehlman (1974) noted that the female burro, when ready to copulate, stood with her tail raised and held out from the hindquarters at a forty-five-degree angle. The vulva were noticeably swollen and urination took place frequently. Females were generally not receptive to males, but agonistic behavior decreased sharply at ovulation. Only on two occasions were females observed presenting themselves to males, and females were never observed mounting other females.

Sexual behavior in males. There are three distinct phases of sexual behavior in the male: courtship, erection and mounting, and intromission and ejaculation. Sex drive manifests itself throughout the year. Courtship is important for successful mating because the jack depends upon erotic stimuli to achieve vascular engorgement of the penis. This is elicited by visual, auditory, tactile, and olfactory sensory modalities. The relative importance of these stimuli varies among species (Hafez, 1962).

Domestic jacks that have been raised properly are ready to breed at 24 to 26 months of age (Hutchins et al, 1973). Data on the ages that male feral burros can successfully compete with older males for estrous females is not available. It is likely, however, that the onset of puberty is of minor significance in the breeding population. King (1965), in discussing reproduction in two species of zebra (Grant's and Grevy's), states that onset of puberty in males has little more than nuisance value because the young males cannot yet successfully compete with fully mature stallions.

Proper copulatory patterns become apparent in many stallions at 10 to 12 months of age. However, domestic stallions are generally not placed in service until they reach three years of age (Ensinger, 1951; Hafez, 1962). In the Pryor Mountain wild horse herd, the testes of stallions do not descend until they are three years of age (Hall, 1972).

Reproductive activity in the stallion, as in the mare, is also influenced by light. Reduced light diminishes the quantity and quality of semen whereas increased light produces an opposite reaction (Nishikawa et al, 1954).

Precopulatory behavior of feral asses consists of the male sniffing the female genital area and then assuming the flehmen posture, or of laying his head on her rump. If the female has urinated the male sniffs the urine and then flehmens. Driving of the jenny by the jack was observed 145 times. One territorial male drove a female seven times in 2½ hours without copulation. Later, the same female was driven nine times with only one copulation. Driving occurred more frequently when other males were present (Moehlman, 1974).

Mounting and copulatory behavior in feral asses is often interrupted by the female's walking or running out from under the male. After copulation the male's behavior depended on the presence or absence of other males. If other males were present and the consort male is dominant, he threatens or chases them; if he is not dominant, he walks away and begins to browse while other males copulate with the female. Copulation frequency is lowest on territorial areas and the highest when the males are outside a territory. One female with seven males in attendance copulated six times in 47 minutes and the following day, with six males present, she copulated five times in 22 minutes (Moehlman, 1974).

Reaction of other burros to mating. Moehlman (1974) often observed that foals place themselves between their mother and the male, and shoved or kicked at him. Adult males ignored the foals. Yearling males and females also crowded behind their

mothers at the approach of a male. Adult males ignored female yearlings but often threatened and chased the males. On two occasions adult females were observed interfering with mating; on one occasion the male was bumped off the female he had mounted.

On non-territorial areas males threatened, pushed one another and often fought, but even with continued aggression completed copulations. One territorial male retained possession of an estrous female for four days. On trips to water he would threaten all other males and then drive the female back to his area.

Foaling. No published information on foaling in feral burros exists.

Moehlman (1974) did not observe parturition; but she did note that two females observed heavy with foal in the evening had foals at their sides the following morning. Tyler (1972) reported that 70% of New Forest pony births took place between dawn and 0900 hours.

Blakeslee (1974) stated that appaloosa mares showed no preference for a birth site other than that they tended to avoid the night grazing area, since most mares foaled at night. Klingel (1969) found that Burchell's zebra (Equus Burchelli bohmi) females seek seclusion from their group when foaling. Free roaming appaloosa mares almost without exception isolated themselves before giving birth, and the dominant mares went greater distances from the group than the subordinate mares (Blakeslee, 1974). Feist (1971) did not observe any births within the Pryor Mountain wild horse herd, but discovered foal skeletons in secluded areas. Tyler (1972) reported that pony mares chose a variety of birth sites, sometimes secluded, and sometimes near their group companions or close to busy roads.

With normal presentation a domestic mare foals in fifteen to thirty minutes. The foal is usually born while the mare is lying on her side with her legs stretched out. In normal birth the front feet, with heels down, appear first, followed by the nose which rests on the front legs. The hind legs and feet appear last (Ensminger, 1951).

Blakeslee (1974) was told by the owners of the free-roaming appaloosa horses that any birth on the open range which lasted much longer than 10 minutes meant that the mare was having difficulty. Tyler (1972) observed a pony birth that was completed within 25 minutes from the time the mare lay down. Appaloosa mares generally give birth while lying in an upright position with the forelegs stretched out in front and the body

weight resting on the sternum (Blakeslee, 1974). New Forest ponies deliver while lying fully recumbent (Tyler, 1972).

Food Habits

Probably the most important change that occurred in the evolution of the Equidae was the transition from browsing to grazing habits.

The teeth of early equids were efficient for eating a large variety of foods as long as the food was soft and did not wear down the teeth too rapidly. These early animals could not have lived on grass even if it were available because it would have worn out their teeth at an early age.

As grass became more abundant (determined from fossil grass seeds) many browsing animals unable to adapt to this food disappeared. The Equidae exploited this change by evolving teeth that permitted them to change from browsing to grazing. This change in tooth pattern developed during the Miocene and has not changed a great deal since then.

After the new type of dentition developed, equids could eat most any vegetable matter including harsh prairie grasses. Three main changes occurred: tooth pattern altered to permit grinding; crown height increased to give longer life to the teeth; and a cement layer developed. The cement filled the valleys and pits in the teeth and prevented food from lodging and decaying; it also prevented the brittle enamel crests of the teeth from breaking.

The tooth system of present-day equids is highly specialized for eating grass which, due to its high silica content, is a very harsh food. As a result, the teeth of horses wear down rapidly and, as they wear, the teeth continue to grow and enable a grinding surface to be maintained at the same level. When the teeth are worn to the roots and can no longer grind, the animal starves. Generally, most wild equids die of other causes before this occurs (Simpson, 1951).

As the teeth of equids changed, digestive adaptations also undoubtedly occurred, but since fossil records leave no evidence, this cannot be substantiated (Simpson, 1951).

The digestive tract of the equidae is smaller than that of a ruminant and unable to handle as much roughage. However, since bacterial action similar to that in ruminants takes place in the caecum and colon, the equids do not need high quality protein in their diet. This is not true of young colts, however,

since much less bacterial synthesis takes place (Ensminger, 1951). Hanauer (1973) describes the digestive system of the horse, which is similar to that of the burro. The esophageal and intestinal opening of the horse lie close together in the stomach, enabling water to pass quickly through the stomach and small intestine. No food leaves the horse's stomach until it is about two thirds full. As the horse eats, partially digested food passes out into the small intestine in a continuous stream--as a result, up to three times the capacity of the stomach may pass through it during a large meal. Emptying of the stomach slows only when eating stops, and the stomach never becomes empty unless the horse has not eaten for several days. Some of the digested food is absorbed by the stomach but mostly in the intestines. Within the small intestine the food remains quite fluid and passes through rapidly.

The large intestine is divided into five components: the caecum, large colon, small colon, rectum and anus. Some bacterial action and synthesis of vitamins takes place in the caecum, but the greater part of digestion, including bacterial action and absorption of nutrients, occurs within the large colon.

The efficiency of the extraction of protein from foods of various composition is similar for cattle and horses (Glover and Duthie, 1958).

Bell (1971) discusses the migratory grazing patterns of the zebra (E. burchelli), the wildebeest (Connochaetes taurinus), and Thomson's gazelle (Gazella thomsoni) on the African savannah, three species of ungulates of various size. The migrations result from the transition from a wet season to a dry season, and species of animals follow one another in a characteristic sequence based on physiological needs for different tissues of the grasses and herbs. Changes in the availability of plant tissue determine the order of movement. The zebras lead, followed by the wildebeest and Thomson's gazelle. The earlier members of the succession open up the dense stands by grazing and trampling so that the following animals can select the diet they need. The author explains how non-ruminants are almost as efficient as the ruminants in extracting protein from various food components, by describing the amount of lignin in various types of plant cells and the manner in which the ruminants and non-ruminants are able to digest and assimilate the food available in various types of cells. Bell states that little information is available on the nutrition of non-ruminants other than the horse, but since the horse, zebra, and ass are close relatives their digestion and nutrition probably resemble one another. The ruminant maximizes the use of protein at the expense of energy. The

The mechanical and chemical breakdown of plant cells within the rumen is so thorough that there is relatively complete extraction of the cell contents. This process of recycling for efficiency limits the passage of food through the digestive tract. When the ingested food contains large quantities of lignified cell walls the rate of passage is slowed and the overall assimilation of protein may be quite low. Under these conditions the animal may not be able to meet its maintenance requirements unless it has the opportunity to selectively graze components of the vegetation that contain cells with thin walls (small amounts of lignin) and a high concentration of protein.

In the horse, fermentation of cellulose occurs in the colon and large intestine, but the simple stomach is the principal site of protein extraction. The slow process of cell breakdown that occurs in the ruminant is avoided and the protein is immediately assimilated as amino acids. The horse achieves efficiency in protein extraction nearly equal to that of ruminants through quantity rather than quality. Food passes through its digestive system almost twice as fast as it does in the cow; therefore the horse can support itself on forage too low in protein to support a cow or other large ruminant, but it must maintain a much higher rate of intake.

Alexander (1963) reported that food remains in the digestive tract of horses from 15 to 48 hours; in cows, markers were not excreted until 70 to 90 hours after administration. In comparing the rate of cellulose digestion in the caecum and colon of the horse with that in the rumen of cattle it was found that the rate of digestion in all parts of the horse colon was faster than in the rumen of cows.

A relation also exists between the biomass of animals and their metabolism. In general, the smaller the animal the higher the metabolic rate; but there is a degree of overlap between ruminants and non-ruminants from the effect of body size on metabolic rate. For relative maintenance (unit weight per unit time) small animals need more protein and energy than large animals. They will lose weight more rapidly and compete less effectively than a larger animal if they are both on an equal sub-maintenance diet.

The reverse is true for an absolute maintenance (per animal per unit time) diet. With equal quality of food intake the smaller animal needs less food and as a result has more time to eat enough for maintenance. The smaller animal can thus afford to be more selective in his grazing habits and survive on a sparse food supply which would starve the larger animal (Bell, 1971).

No full-scale studies of burro feeding habits that include observation, fecal analysis, species composition, abundance and productivity have been done. Such research is badly needed.

The year-round food habits of feral burros are presently being studied by Drs. Ohmart and Woodward at Arizona State University. Their study area occurs in the Colorado River valley of California and Arizona. Early field observations indicate that in the spring burros relish cured annuals (especially Plantago) and consume entire plants, including the roots. They closely crop and stunt Ambrosia dumosa but eat only the new growth and flowers of Lycium andersonii and Krameria grayi. They also relish Fouquieria splendens. They damage Ocotillo by stripping the bark and breaking the stems. The Ocotillo did not usually die, but the regrowth was denser and thornier. The burros avoid or ignore species of Lupinus, Cryptandus and Encelia. The authors include a tentative list of plants within the area which the burros have been observed eating (see Appendix 5).

Browning (1960) examined 20 burro stomachs to determine their forage preferences in Cottonwood Canyon of Death Valley National Monument. He reported that forbs comprised almost 65 percent of their spring diet and browse made up over 75 percent of their fall diet. Grass occurred in about half of the stomachs and amounted to ten percent in both spring and fall diets.

McMichael (1964) examined the stomach contents of nine burros collected in February, April, May, and July. Laboratory analysis revealed that the stomach contents consisted of 1 percent grass, 11 percent shrubs and 88 percent forbs.

Jones (n.d.) reported that in the Panamint Mountains of Death Valley National Monument burros ate creosote bush (Larrea diverticata) at the lower elevations and that Franseria was nearly a remnant plant. At the higher elevations the grasses and forbs had nearly disappeared; the burros were not only using Lupinus heavily but often uprooted the plants. Sumner (1959) reported that burros ate four-winged saltbush (Atriplex canescens). Welles and Welles (1960) reported that in a canyon used by both bighorn and burros the latter concentrated on white bursage (Franseria dumosa). Farrell (1973) reported that burros severely damaged palo-verde trees (Cercidium sp.) by breaking off branches one-half to two and one-half inches in diameter, then chewing for a short while before dropping the branch and ignoring it.

Moehlman (1974) states that feral burros in the area of her study were mainly browsers, and related this to the scarcity of grasses and annual plants. Preferred browse species were Lycium andersonii, Coleogyne ramosissima, Grayia spinosa,

Acamptopappus schockleyi, Tetradymia spinosa, and Dalea fremontii. Burros occasionally ate other plants, including Eurotia lanata, Haplopappus cooperi, Hymenoclea salsola, Ephedra nevadensis, Sphaeralcea ambigua, and Franseria dumosa. They ate a grass, Stipa speciosa, when it was available.

Appendix 3 lists plant species found in stomach samples of individuals collected in the Cottonwood Mountains, Death Valley National Monument, and China Lake Naval Weapons Reserve, California (Moehlman, 1974).

Moehlman (1974) reported that burros browsed an average of 38.5 seconds on an individual shrub, then moved to another plant. This resulted in a light hedging rather than heavy use of any individual plant. On three occasions they were observed eating cottontop cactus (Echinocactus polycephalus) by pawing at the plant with a front hoof and then removing the fleshy interior with their upper incisors. Only one cactus of several heads were eaten in this manner. They were also noted pawing under shrubs to get needlegrass (S. speciosa).

Moehlman (1974) compared horse and ass skulls and found that the ass has a small projection on the mid-dorsal premaxilla which is not found on the horse. She postulates that this projection may serve as an attachment site for muscles that provide the ass with a much more mobile upper lip than the horse. Thus the ass is able to curl his upper lip around the thorniest of vegetation.

Senses

No research has been conducted into the sensory mechanisms of feral burros, therefore material pertaining to the horse has been used. The two species are probably quite similar in their sensory makeup.

Vision. The color-blind horse sees the landscape ahead as a mosaic of various shades of gray caused by differently lighted areas. Its eyes cannot break up a visual image into individual items such as trees, grass, fences, etc. Movement is recognized by changes in brightness, tone, and the relationship of the moving subject to fixed objects. Any object that remains perfectly still may go unrecognized.

The eyes of the horse are set on the side of the head so that each eye receives a different scene. When the images are superimposed the horse views a flat panorama. The eye lens is nonelastic and the retina is arranged on a slope with the bottom of the retina nearer the lens than the top.

Neither the cornea nor the lens of the horse's eye is truly shaped, thus it suffers from astigmatism. For this reason the horse has trouble focusing on a nearby subject and often mistakes a harmless object as something dangerous. To focus on objects at different distances the horse raises or lowers its head so that the correct part of the retina is brought into play in focusing on the subject. Although the horse possesses eye muscles useful in turning the eye in various directions, they are seldom used primarily because of the position of the eyes in the head and the fact that the neck is long and moveable. Generous movement of the head is absolutely necessary if the horse is to focus its eyes properly. When grazing, the horse is able to view objects from every direction by moving its head. Objects to the rear can be seen between its legs. A horse sees most and farthest when it stands still with head erect and the forehead and muzzle perpendicular to the ground. In this position it can probably see all the landscape for several hundred yards around by alternate use of frontal and lateral vision. When horses look straight ahead the head is moved into position and the ears point forward. When a horse is paying attention to objects on either side of the body it cannot see very well in front of the body; in like manner when it is staring straight ahead it cannot easily see what goes on on either side (Smythe, 1966).

Smell and taste. It is often difficult to disassociate taste from smell in horses. Some horses will accept a strong smell and refuse upon taste, whereas others will reject strong-smelling substances without tasting. Domestic horses have a liking for salt, sugar, and honey. They dislike most strongly aromatic substances such as peppermint, eucalyptus, thyme, and fats or anything of a meaty nature.

The true nostrils of the horse open into the nasal chamber which contains large turbinated bones that are very brittle and covered with mucous membranes. The nasal surfaces contain areas of closely packed smell buds and olfactory nerve endings. It also has a false nostril which runs upward and ends in a blind pouch. Horses are nose breathers with the nostril size varying considerably among individuals. They do not open their mouths or drop the tongue until completely exhausted (Smythe, 1966).

The muzzle of the horse is soft skinned, flexible and capable of receiving environmental stimuli. Sensory cells and nerve endings embedded in the connective tissues of the lips and nostrils, plus the long bristling hairs that stick out in all directions, all can receive sensory stimuli. The region of the lips and nose perform functions of the hand in man. The nose of the zebra is far more useful for orientation and warning against surprise attack than is the eye (Burkhardt et al, 1967).

The soft palate of the horse is large and somewhat pendulous and used to block the open end of the larynx in order to prevent choking when the horse is eating or drinking. It may also drop into the pharynx and limit mouth breathing when the horse is exhausted or nearly so.

Stallions have an acute sense of smell and can smell a mare in estrous at a considerable distance if she is upwind (Smythe, 1966).

The horse's ability to smell distant water has saved the lives of many early riders. Old time mustangers, when following a band of wild horses, were very careful not to change their clothing because their odor would change. Most horses can smell snakes, and reports exist of a horse that could track deer. South American horses gallop about in the dark and avoid the burrows of hundreds of Vizcacha (Lagidium sp.) holes, probably by smelling them (Dobie, 1952).

Domestic horses will eat a great variety of drugs one would expect them to refuse. They are apparently unable to discriminate between edible and poisonous plants and, being unable to vomit, they are unable to get rid of poisonous plants once they ingest them (Hafez, 1962).

Hearing. Horses hear over a great range of frequencies and can pick up sounds too slight for human ears. They have the advantage of a long neck and concave ears that can be moved in any direction to not only pick up sound but also to pinpoint the origin. When a horse pricks its ears, the nostrils also dilate. When a horse lays its ears back on the neck it is either a sign of temper or an indication of stress such as running hard.

Investigators have determined the range of hearing in most domestic animals, but horses are an exception. Little experimental work has been done on their hearing.

Horses communicate with each other and with other animals by means of a number of vocalizations and sounds. Mares communicate to their foals with a wide variety of low-toned whinnies, each of which appear to convey a different meaning. Dobie (1952) states that the scream of a stallion is one of the most terrifying sounds in nature and serves as a warning to stallions and other animals within hearing distance.

Domestic horses appreciate sounds from humans, and there are many stories of grooms who became famous by their abilities to calm frenzied horses by talking, whispering or hissing to them. Highly strung horses often become excited or alarmed by unfamiliar

sounds such as escaping steam, fireworks, thunder, or even the rustling of paper.

Horses can sense very slight ground vibrations through their legs and feet. When grazing, they also detect vibrations through the limbs, teeth, jaws and bones of the head. The footsteps of a man can be picked up in this manner long before they become audible (Smythe, 1966). South American gaucho horses, which lived in a semi-wild state, expressed great fear of Indian attacks. They would often come running home when an imminent Indian attack was still a day's ride away. A few frontiersmen trained their horses to fear the odor of Indians (Dobie, 1952).

Tactile sensations. In order to maintain its body temperature at about 100.3° F., the horse sweats and shivers. It has the ability to sweat at a moment's notice from exertion, fear, or excitement. The muscular energy expended when such a large animal works hard makes this a necessity. The horse has sweat glands in the neck, certain parts of the back, the shoulders, axillae, and groin, but there are no sweat glands in the skin of the limbs except between the hind thighs. Foam forms on the body and limbs after continued exertion when sweat pours from the suboriferous skin ducts, and a considerable amount of heat loss takes place through water vapor in the breath.

The ability of the horse to fairly rattle his skin to dislodge insects or to remove adhering particles from the skin when rising from the ground is well known. This is made possible by the panniculus muscle which covers the greater part of the body beneath the skin. The same muscle is involved in shivering, which the horse uses to increase its surface temperature when it becomes cold.

Many horses respond very rapidly and often vigorously to skin stimuli; the neck and shoulders, the skin of the lower limbs especially around the feet and the coronets, the heel at the rear of the pastern, and the skin on the ribs and flanks are very sensitive. Most horses appreciate scratching on the skin of the withers and gentle patting of the neck and face (Smythe, 1966).

Horses have certain skin areas that are extremely sensitive to certain irritants, be they vapor, solids or liquids. These include the lips and skin of the muzzle, the skin inside the elbows, groin, beneath the tail, the eyelids and their conjunctive areas, plus the skin surrounding the nasal openings (Hafez, 1962).

Social Organization and Behavior

General. Klingel (1972) documents only a few qualitative differences among all species of equids: the stripe pattern in zebras, dew laps on the mountain zebra (E. zebra), the presence or absence of chestnuts on the inner sides of the legs, and the presence or absence of infundibula in the lower incisors. All species can interbreed in captivity and in most respects their behavior is similar, including fighting, social grooming, mother-foal relationships, and much of their mating and greeting behavior. Considerable differences exist, however, in their social organization and behavior. Klingel states that a comparison of behavior is only possible for five of the six species of the Equidae since little is known about the Asiatic wild ass (E. hemionus). Two basic patterns of social behavior exist. The plains zebra (E. quagga), the mountain zebra (E. zebra), the horse (E. przewalski) and possibly the Asiatic wild ass live in harem groups composed of one to several mares led by a dominant male. Surplus males form groups of their own and the young leave their original family groups in a set pattern. These social units do not establish territories, instead they move freely over their home ranges and share them peacefully with conspecifics. The social organization of Grevy's zebra (E. grevyi) and the African ass (E. africanus) is quite different. There are no personal bonds, other than mare-foal relationships, between any individuals. The animals occur singly, in stallion groups, mare groups, mare-foal groups, and in mixed herds. All of the groups are variable and their composition may change at any time. Some of the males are territorial but do not prevent conspecifics from entering their territories as long as they do not interfere with mating activities. The territories are only defended when a mare in estrous is near a boundary. Once the mare has been driven by a dominant male into a territory or she enters of her own accord the fighting ceases and the unsuccessful males remain at the boundary. Within a territory only the territorial male will court a mare because all the other males are subordinate to him. Within this type of organization there is no order of dominance or leadership. All adult members seem to be of equal rank and only the mare and her foal ever search for each other when they are separated.

Ohmart's (1974) early observations indicate that in general male feral burros remain alone or in small groups of two to five animals unless they locate a female in estrous; then as many as twenty males may gather and attempt to court her. Jennies remain alone with their foals or in a group composed of two (rarely three) females and their young.

Moehlman (1974) did not observe feral asses in large groups unless a female was in estrous or a resource, such as water,

existed in short supply, and these groups stayed together for only one to two hours. Occasionally temporary associations of two to three animals lasted from a few hours to a week. The only bonding between females formed between a mother and her offspring, and these bonds loosened when the youngster approached parturition. Both male and female yearlings often remained with their mother. Jennies displayed a high degree of tolerance for juveniles and sometimes yearlings not with their mothers associated with a non-related adult female. Adolescents occasionally joined adolescent groups or associated with adult males.

Aggressiveness. Individual aggressiveness in vertebrates towards members of the same species expresses itself in two ways: defense of a given territory, or the establishment of hierarchies of precedence within social groups (Collias, 1944).

Due to the potential danger, most mammals avoid fighting if possible. They generally resort first to aggressive display and threats which often result in submission or appeasement by the weaker opponent. Fighting seldom results in the death of the loser unless overcrowding prevails. An unsound environment distorts the normal patterns of social behavior (Scott, 1958). Increased aggression often takes place in crowded populations (Mathews, 1964). Crowding may also produce a reverse reaction when it exceeds certain levels, and animals become passive and nonreactive (Southwick, 1970).

Klingel (1972) describes five phases of fighting among the Equidae: chasing and fleeing, circling, neck wrestling, biting, and kicking. He states that fighting rarely leads to serious injury.

Threat Displays: Moehlman (1974) observed and reported on aggressiveness in the feral asses she studied. Most threat displays showed gradations of intensity. Frontal threats were used mostly to increase the distance between males, or by males to restrict the females' movements. Expression consisted of laying back of the ears, often with open mouth, and running or walking toward the receiver. These threats were often intensified by a lowering of the head and stretching of the neck.

Rear kick threats were mostly made by adult females against males approaching from the rear. This kick action rarely resulted in the male's moving away. Between males the kick threat usually caused the approaching male to lift his head up and back and then walk away. Female kicks were usually made with only one rear hoof whereas males sometimes used both hind hooves. The position of the ears varied from flat against the neck during an intense threat to only halfway back for a mild threat. Males laid their ears back to females only when driving them. Open mouth threats took place usually between males and prompted

the receiver to move away. Bites were mainly male to male and often directed to the head and neck or sometimes to the loin, legs, or even the ears. Tail switching often occurred when a mare was threatening her foal or by a male when near an estrous female, presumably as a warning to other males.

Moehlman (1974) stated that fighting occurred almost exclusively between males and consisted of biting, kicking, rearing, growling and grunting. Fights were always highly vocal with both animals braying between contacts. Males did not appear to be affected by hard kicks and usually walked away from a fight with only a few scars or a broken ear.

Home range. Burt (1943) defines a home range as the area over which an animal or a group of animals travel in pursuit of their routine activity. It may have no clearly defined boundaries but it must produce the energy requirements of the specific group of animals that occupy it. It implies a self-imposed restriction of movement. Every species of mammal moves within a home range of some type. These home ranges may be stationary or they may change with conditions. Home ranges often overlap and migratory animals may have more than one home range.

Tyler (1972), who studied the semi-wild New Forest ponies in Great Britain, stated that home range was correlated with the topography and the nature of the habitat. Four requirements were necessary: a grazing area, shelter, water, and shade. When these were close together the home ranges were often small, about 200 acres. The home ranges of the different groups were very stable and often almost identical; but when they overlapped each group tended to use a different part of the grazing area.

Lorenz (1963) lists several species of animals--bison, antelope, and horses--that do not maintain strict home ranges or display territorial jealousy if there is enough food for all.

Moehlman (1974) states that there is no information available on the home range size of the native African ass (*E. africanus*) or of Grevy's zebra (*E. grevyi*). Feral asses in her study area had home ranges smaller than the plains zebra (*E. quagga*) but similar in size to Hartman's zebra (*E. zebra hartmannae*) and the semi-wild New Forest ponies in Great Britain.

She observed that home range size of female burros varied from 0.50 to 7.2 square miles in size, that they overlapped extensively, and were marked by regular seasonal patterns of movement that differed among individuals. Home ranges of males also varied in size but were larger than those of females (.90 to 15.67 square miles). Males also displayed a seasonal pattern of movement and as a result some of them were absent from her study area during the winter. Others migrated into canyons to the north.

Known individuals made major use of the northern portions of their home range during the winter, and their distance from water ranged from three to six miles. During May through July most of the population remained within two miles of water. Young foals may limit the distance females move from a water source. Eighty-one percent of the females with foals less than 1½ months of age were never observed more than a mile from water. Lactating females may be under greater water stress than other members of the population (Moehlman, 1974).

Territoriality. A territory in animal populations consists of that part of the home range which is protected from individuals of the same species either by fighting or by other aggressive action. Territoriality is so widespread among the vertebrates and in many of the invertebrates that it must be considered a basic animal characteristic. Although it does not exist in all animals, nor is it always developed within strict boundaries among the animals that possess it, the potential exists whether the animal displays the characteristic or not (Burt, 1943).

Ohmart, whose study of feral burros is still in its initial stages, reports that no definite signs of territoriality or dominance among jacks have been observed. This may be due in part to the large number of indistinguishable gray males, which complicates accurate observation. He hopes to remedy this with additional identifying collars.

Moehlman (1974) concluded that an expression of territoriality in animals is dominance within a spatial framework. It differs from dominance of a specific object or dominance independent of a space reference. She describes two distinct classes of adult male feral asses, one territorial, the other non-territorial. About 10 percent of the males occupied small territories from March through August, which were mutually exclusive and did not overlap and ranged in size from .31 to .80 square miles. Territorial boundaries were not defended and conspecifics were permitted to enter the territories. However, only the dominant male courted estrous females within a specific territory. These territorial males left their areas only to go to water, seldom remained away more than an hour at a time and did not use any one portion of their territory more than another.

The social organization of feral asses differs from that of all other ungulates because mating activities occur both off and on territorial areas and both territorial and non-territorial males participate. Territories in feral asses are mating territories complicated by the existence of non-territorial breeding, but even this is often dominated by the territorial males (Moehlman, 1974).

Spatial distribution. Foals less than a month old spend most of their time within a yard of their mothers. As they grow older they often move as far as four yards away; at all ages they occasionally wander over fifteen yards away from their mothers. A strong tendency toward bonding exists between adult females and their adult female offspring who spend 69 percent of their time within one to four yards of each other. Adult females maintain larger distances from other adult females than from adolescent females. Most of the time males kept a spacing of twenty or more yards between them. They only came together (within a yard) occasionally for mutual grooming, greetings or fights. Female-male spacing was the greatest; almost 50 percent of observations were twenty plus yards apart, however, this changed drastically when females came into estrous (Moehlman, 1974).

Vocalizations. Brookshier (1974) devoted an entire chapter of his book on the burro to the bray and states that it is the most distinguishing characteristic of the burro. He tells many tales from around the world all connected to the bray; some of the stories related to folklore, some anecdotal, some proverbial and many derogatory to the burro. He states that the voice of the jenny is more moderate than that of the jack and the bray of the gelding is even lower in pitch. All burros possess a range of vocalizations that express hunger, happiness, sadness, warnings to other burros, male to male mating challenges, and in addition the half-cry sniffling plea of a pet burro for a tidbit.

Waring (1971) identified seven basic categories of sound emitted by horses: squeals, nickers, whinnies, groans, blows, snorts, and snores; the first four vocal, the latter three non-vocal.

Moehlman (1974) recognized five categories of sounds emitted by feral burros: the bray, grunt, growl, whuffle and snort, with the latter being non-vocal, and recorded them. Analysis of the sonograms indicated that individuals have unique and identifying calls that are greatly affected by the context of the particular situation. The bray is long in duration (up to 24 seconds), loud, and can often be heard at a distance of two miles. It consists of a pattern of exhalations and inhalations, structured harmonically and emitted in several different contexts. Adult males, particularly territorial males, bray soon after dawn; they often bray as a greeting to each other, when threatening another male, or they may bray during pre- and post-copulatory behavior. Yearling males seldom brayed and young males only when adult males were not present or when a large number of animals were braying at the same time. Braying by a male, attendant to an estrous female, often attracted other males but if a braying subordinate was threatened by a dominant male he usually stopped

braying. Foals bray when they are separated from their mothers; their bray is softer, lower pitched and more irregular than that of an adult. Females were not observed braying.

The grunt (0.2 second) and growl (0.7 second) are both atonal vocalizations used in agonistic situations either singly, in succession or preceding or following a bray. The whuffle is an atonal sound of low intensity used in an approach or searching context and varies in length from 0.1 to 0.6 second. It appears to serve as an individual distance reducing vocalization. Females use it singly or in succession when searching for their foals, and males, when approaching other animals, use it in terminating a low intensity bray. The snort is an atonal sound signal that carries only a short distance. Duration varies from .3 to .35 second. It often produces an alert response from nearby animals.

Postures and facial expressions. Moehlman (1974) reported a facial expression in feral asses that has not been observed in other equids. Males were observed lowering their heads and extending their upper lips beyond the lower jaw. They did this when approaching a female from the rear, when driving a female or when mounting or copulating. Males were also observed assuming this expression when they were kick-threatened by another male.

The jawing or snapping expression in equids, which consists of vertical movement of the lower jaw up and down, has been described by Antonius (1937) and Trumler (1959). Zeeb (1959) termed it "unterlegenheitsgebarde," meaning a submissive expression. Feist (1971) reported many observations of this expression in young males of the Pryor Mountain wild horse herd. Both Tyler (1972) and Klingel (1967) reported observing the expression in young female ponies and zebras, respectively, when copulating. Moehlman (1974) reported that young female feral asses adopted the expression when they were mounted by or copulated with a male or when he laid his head on their rump. It was also observed during male to male mountings, nose to nose greetings of males and when a male kicked at another male.

A facial expression among female equids in which the lips are drawn back exposing the incisors has been described in zebras and Asian and African asses by Antonius (1937) and Klingel (1967). Moehlman (1974) also noted this expression along with jawing or the snapping action in female feral asses when they were mounted or when they copulated.

During estrous, female feral asses assume a distinct tail posture by raising the base of the tail so that it does not make contact with the rump.

Yawning in feral asses usually occurs after resting, in threat situations where it is generally a response by the receiver and before or after masturbation by males. It consists of wide open mouth with teeth exposed, eyes closed, ears flopped and the lower jaw to one side.

In an alarm situation feral asses assume a stance with their weight on all four feet, head turned toward the potential danger. This alert position is often accompanied by a warning snort. If the animals flee, it is usually for only a short distance, then they stop and again assume the alert posture. Females with young foals, however, do not stop and look back and sometimes run a mile before stopping.

Schneider (1930, 1931, 1932a, 1932b) described the flehmen in a wide variety of ungulates. Hafez et al (1969) states that this expression is common in the precopulatory patterns of many ungulates. Estes (1974) states that during the flehmen, urinary odors are apparently assayed in an accessory olfactory system specialized to detect concentrations of sex hormones. In assuming the flehmen posture the animal extends its neck, raises the head with muzzle pointing upward, exposes the upper teeth and gums by drawing back and puckering the lips, and wrinkles the nostrils so that they appear to be closed. Tyler (1972) observed the expression in both sexes and all age classes of the New Forest ponies as a reaction to some smell. Blakeslee (1974) reported similarly on the free roaming appaloosa horses that she studied. She observed the expression in a variety of situations other than smelling urine on the ground. Feist (1971) tallied fifty-five exhibitions of this expression in the Pryor Mountain wild horse herd. All of them were related to olfactory responses and all of them were performed by males.

Moehlman (1974) reported that male feral asses assumed the flehmen posture in a variety of situations: after smelling an old urination spot on the ground, while urinating, after smelling their own or another male's urine or defecation, after smelling a recent female urination spot or after smelling her genital area, and after mounting or copulating with a female. On forty occasions she observed females urinating when males were present. In about 72 percent of these situations the males flehmened after smelling the urine. About 18 percent of the males did not flehmen but urinated over the spot; in close to 20 percent the males made no response. Adult female asses showed no response to urination, either their own or to other age or sex classes, and were never observed in the flehmen posture. However, female foals and yearlings were occasionally observed exhibiting the posture and the author observed it among domestic asses when no males were present. In circumstances other than olfactory a male was observed in the flehmen posture after he had been kicked in the nose by another male.

The author noted that when a male flehmened after smelling a female's urine, the posture served as visual attraction to any nearby males who, when they saw the flehmen, approached, smelled and then also flehmened. She concluded that the expression did not appear to be a learned reponse because she observed a two-day-old foal exhibiting the flehmen while urinating.

Facial expressions and posture assumed by the Equidae when greeting each other have been described for horses by Antonius (1937), Trumler (1959) and Tyler (1972), and for zebras by Klingel (1967) and Joubert (1972).

Moehlman (1974) reported that feral asses approach each other with ears forward but in many cases moved the ears to a side position as they came close to each other. Most observations of greetings took place between adult males. Females seldom greeted each other and foals usually greeted adult males. This consisted of a simple nose to nose contact after which the foal walked away. Males greeted each other in a nose to nose, nose to genital area, nose to anus, or, in a few cases, nose to side contact. About 12 percent of the greeting contacts were preceded by kicks or fights, and only a very small portion ended in mutual grooming bouts. Since most greetings between males resulted in one of the participants jerking his head up and back, the author postulates that this action may indicate the subordinate status of the head-jerking male.

Grooming. Hafez et al. (1969) state that domestic horses do not groom each other, but Feist (1971) reported that mutual grooming took place commonly among the Pryor Mountain wild horses and Tyler (1972) observed all forms of grooming in the New Forest ponies as did Blakeslee (1974) among the semi-wild appaloosa horses.

Trumler (1959) classified grooming in zebras as follows: localized muscle contractions, shaking, striking one part of the body against another or against the ground, rubbing and rolling, scratching, nibbling, and social or mutual grooming.

Moehlman (1974) reported that feral asses mutually groom by standing nose to tail and scraping each other's hide with their upper incisors. Males groom more often than females. Yearlings only occasionally groom each other. Foals were involved in almost 50 percent of the observations of mutual grooming, usually with their mothers. The foal most often initiates the grooming, but the adult generally terminates it. Neither sdult males or females had special grooming partners but groomed with any temporary associate. Adult males and females were never observed mutually grooming.

Individual feral asses spend little time self grooming, but when they do they use their teeth or hooves to reach almost any part of their bodies, or they rub against rocks or posts. They use their hooves to scratch with a back and forth movement, and their upper incisors in a uni-directional motion to scrape their skins. Rubbing against fixed objects was usually done to the side of the neck and body.

Hutchins et al (1973), writing on domestic donkey care, states that donkeys thoroughly enjoy rolling and that a daily dust bath is as necessary to a donkey as food. Donkeys never shake after rolling or dusting as horses do.

Both Feist (1971) and Blakeslee (1974) report that horses often roll in mud and water. Brookshier (1974) states that burros never roll, wade or lay down in shallow water or mud as horses do, and it is often difficult to persuade a burro to cross any watercourse. Moehlman (1974) reports that rolling or dust bathing by feral asses usually occurs when the animals walk to or from water. Dust bathing sites consist of patches of bare ground or ridges above the watering area. Rolling is a social action in which groups of animals approach a rolling site and then roll in sequence. After rolling they usually stand up and shake. A certain amount of play among foals is associated with rolling; young foals often half-fall on their mothers or siblings and bite their heads or necks as the older animal lies in the dust.

Play. The word play is a human concept applied to any activity other than work. The term is difficult to apply to wild animal activity or behavior; since animals do not work (in the human sense of the word) they cannot be said to play.

Human play does not have survival value; however, in animals it must be assumed that it does have a value. Play occurs among animals only when they are free of environmental or physiological stresses. It is a widely held view that play is preparation for adult activity, and the animals that have an opportunity to play prior to becoming adults have a selective advantage over those animals that are denied this opportunity. However, it has never been clearly shown that animals prevented from playing are less efficient as adults than those that play (Loizos, 1965). Play increases locomotive skills and may be used to test social dominance (Hafez et al, 1969).

Play among wild or semi-wild horses has been reported by Feist (1971), Tyler (1972) and Blakeslee (1974). Feist observed play among foals but rarely in other age groups because if it started the dominant stallion quickly ended it. Tyler noted differences between the play of fillies and colts over four weeks old. Colts spent long periods play-fighting, whereas fillies seldom

played and when they did, it often ended in mutual grooming. Blakeslee did not note any difference between the play of male or female foals among the appaloosa horses she studied.

Moehlman (1974) observed play in feral asses only between yearlings and by individual foals. Foals played near their mothers or other adults by running, turning, quick stopping, pivoting, leaping, and kicking. They also played with objects such as stones or twigs. Yearling males play-fought in patterns similar to those of adult fighting. The author never observed play-fighting between foals, although she cites such activity as occurring in other populations of asses, both domestic and feral.

Sleep and rest. In lying down, the horse brings all of its legs under the body, bends its knees and hocks and permits the chest to touch the ground before the hind quarters. When down, the horse either rests on one side of its chest with a fore and hind leg underneath or it lies on its side with all legs stretched out. In getting up, the forelegs are stretched out first followed by the rear legs pushing up the hindquarters (Hafez, 1962). This movement of the forelegs as the initial action in getting up is the reason why a horse with a broken foreleg cannot get up.

Moehlman (1974) describes a similar sequence of movement in feral asses when they lie down. Individual animals stood over the spot on which they were going to lie down or roll on with their head lowered and almost touching the ground. Occasionally they smelled the spot or stepped forward or backwards before flexing their legs and dropping to the ground.

The ability of equids to sleep while standing differs from most other mammals. Moehlman (1974) cites other writers and states that feral asses can rest in a standing position due to a locking action of the joints by ligaments. The knee, pastern and fetlock joints can all be locked so that no muscular energy is necessary to maintain the posture of the locked limb. Likewise, ligaments in the neck (the ligamentum nuchae) are elastic, reducing the amount of energy needed to hold the head up when the animal is resting. She reported that feral asses rested many times during the day in periods lasting from one minute to over two hours. When animals were congregated, rest periods were sometimes coordinated but coordination of rest periods took place most often only between a female and her foal.

All age classes rest in either a standing or lying position. However, adults spend more time resting in a standing position than foals, who generally lie down when their mothers are nearby. One male spent 64 percent of his resting time in a standing

position. This ability to sleep in a standing position may be adaptive for predator evasion. Thus, when flight is required the animal does not need to waste time in getting up from the ground.

Occasionally entire groups rest, but they never all lie down at the same time. Similar behavior has been reported in horses (Ensinger, 1951; Dobie, 1952; Hafez, 1962; Feist, 1971), and Klingel (1967) noted that resting bands of plains zebras always had at least one member standing alert.

Water and watering behavior. In the Gobi Desert, wild asses occur in greatest abundance in those parts of the desert where there is no water (Andrews, 1924). Animals that live in hot, dry, desert environments can combat the heat in three ways: they avoid the heat, put up with it, or reduce its effect by evaporating water. The size of the animal is important. Small animals have little defense against overheating; they do not sweat or pant, and because of their relatively large body surface they need too much water for effective heat dissipation. Their only solution remains avoidance, which they accomplish by remaining in burrows during the heat of the day. Large animals combat heat by evaporation of water, and where water intake is limited the only animals that prosper are those that can reduce their output. These animals have kidneys that secrete a highly concentrated urine, and intestines that can remove water from fecal material. Many of them are also aided by mechanisms that reduce evaporative losses, which comprises the largest single factor in their water economy. The most successful animals possess efficient means of controlling this factor (Schmidt-Nielsen, 1964).

The burro looks upon water as a necessity for life--drinking only. He never thrusts his muzzle deep in a trough as a horse will do, nor does he wade or roll in water or mud like horses. A horse will often founder when dehydrated if permitted to drink all the water he wants; a burro never over-indulges no matter how thirsty he is (Brookshier, 1974). Schmidt-Nielson (1964) states that donkeys always seem to drink an amount closely equal to the amount lost in dehydration, and can recoup losses as great as 20 percent of body weight in less than 2 minutes. If more water is available the donkey will be completely disinterested in drinking any more than it needs, even several hours later. Schmidt-Nielsen (1964) postulates that water intake is metered by some neurological mechanism.

Only a few researchers have studied water economy in asses. Schmidt-Nielson (1964) compared the water economy of the donkey with that of a camel in the Sahara Desert. During the winter months when water was not necessary for heat dissipation, investigators watered a donkey and a camel every day. The

donkey drank 3.52 percent of his body weight (approximately 100 kilograms) each day and the camel, 1.47 percent of his body weight (near 300 kilograms). Based on these figures and an assumption that both animals have the same degree of tolerance to desiccation of the body (30 percent weight loss), the author estimated that the donkey should be able to survive for twelve days and the camel thirty days without water. The estimates are based on cool conditions, dry feed and an equal rate of water loss. If the vegetation contains some moisture the camel can go indefinitely without water. The same is true for the donkey if the vegetation is succulent. However, when summer comes and the vegetation dries, body temperatures must be regulated through water use. Under these conditions both animals have to drink.

Maloiy (1970) states that the donkey has a fluctuating body temperature (35° to 38° C.) that aids the animal in conserving water. However, Schmidt-Nielsen (1964) maintains that the primary reasons why the camel is more efficient than the donkey in conserving water include the facts that the donkey's body fluctuations are smaller, its protective fur of the donkey is thinner, and the behavioral adaptations of the donkey which reduce heat gain are not as efficient.

Yousef et al (1970) and Bullard et al (1970) studied dehydration and rehydration in burros under natural conditions in the Nevada desert. They reported that dehydration amounting to 9, 14, and 20 percent of body weight did not greatly alter the volume, the concentration or the circulatory adequacy of the blood. Rehydration by drinking was rapid and overhydration did not occur. They concluded that this was a likely explanation of the burro's ability to maintain its well-being in a desert environment. Maloiy (1970) studied the water economy of the somali donkey in Kenya, Africa, and reported that donkeys have high tolerance to dehydration and that more water was lost through fecal and evaporative routes than through the urine. The urine volume was low even when water was available. Water loss was reduced by 65 and 52 percent respectively when animals were dehydrated at 22 and 40 degrees centigrade. The donkeys survived a water loss of 30 percent of their original body weight even at an ambient temperature of 40° centigrade. The deficit was restored by drinking 24 to 30 liters of water within a two to five-minute period.

After a 20-mile walk in the Nevada desert and 36 hours without water, a burro drank 12.2 liters of water within a 5-minute period (Dill, 1938). Schmidt-Nielsen (1964) stated that one of his study donkeys of about the same size as that used by Dill could easily drink 10 liters of water in 70 to 80 seconds when dehydrated. When the animal was dehydrated to 30 percent

loss of body weight, it was unable to drink immediately enough water for the entire loss. On two separate occasions it drank over 20 liters of water within a few minutes or more than one-fourth of its body weight.

Moehlman (1974) noted that individual asses approached the water trough in her study area with caution, especially females with young foals. She attributed at least part of this caution to the presence of an observer at the water site. Individual asses drank for periods of up to almost five minutes at a time. Females, on an average, drank longer than males. Estrous females, due to harassment by males, often had trouble drinking and would remain at the water source for long periods. After watering, some asses remained standing near the water and slept; and a few males remained near the water all night, greeting and interacting with all arrivals. Foals younger than two to three months did not drink at the trough although they would sometimes dip their muzzles in the water and then raise and shake their heads. Older foals adopted drinking patterns similar to adults. Generally, watering took place in late afternoon, but among individuals the time of watering appeared to be random as some animals watered at all times of the day. Peak periods for drinking during March occurred from 1800 to 1900 hours with a smaller peak from 0000 to 0100 hours. During summer, peaks occurred from 1900 to 2100 hours. During the summer many animals came to drink at least once in each 24-hour period, and females with foals drank two to three times a day. A seasonal migration of feral asses apparently resulted from their water needs. During the hot months the animals remain fairly close to water. This was especially true of females with young foals, as over 80 percent of the sightings of these females during May, June and July were within a mile of water. As fall approaches, the animals disperse and are found at higher elevations and farther from a water source (3 to 6 miles). During September of 1970 and April of 1971, substantial numbers of animals were sighted five to six miles from water (Moehlman, 1974).

There are many reports that feral burros concentrate around desert water sources during the hot months. It is said that they foul the water by trampling and defecating, that they often drive away or by their presence prevent bighorn sheep (Ovis canadensis) from watering, and that they also often prevent livestock from watering (Dixon and Sumner, 1939; McKnight, 1958; Buechner, 1960). Weaver (1959) reported that feral burros can and do totally usurp small water supplies from both natural and artificial tanks as well as from small seeps and springs. When water exists in short supply or is depleted they paw at and destroy pipelines and break cement and masonry pools. In some instances their trampling tactics around a spring may reduce or entirely stop the flow of water. They also foul some

waters with an accumulation of excreta so that other animals either leave the area or use the water only as a last resort. The author also states that when a small water source is dry they sometimes uncover water for themselves and other animals by pawing out large holes in sand or gravel-filled natural tanks. McKnight (1958) has seen holes four to five feet deep dug by burros searching for water.

Welles and Welles (1961) found no evidence to support any of the claims concerning bighorn and burro animosity. He stated that some of the largest populations of bighorns in Death Valley feed and water in the same area as burros. Weaver, in a later paper (1972), reported that bighorn sheep and burros will water at the same source without conflict, but that the burro is always the dominant animal. The sheep will wait for the burros to leave before watering or they will leave the water if burros arrive. Sanchez (1974) also reports both animals sharing the same water source. Both authors state that the biggest problem is depletion of the vegetation near the water, which is a necessity for bighorn sheep with lambs.

In east Imperial County and northeastern San Bernardino County, California, serious competition for water exists between bighorn and burros. The burros usurp the water from the seeps, springs and tanks and, when this is gone, they drink from the nearby Colorado River. The bighorns sometimes will die of thirst rather than go to the river for water (Weaver and Mensch, 1969; Weaver and Hall, 1971).

Scent or visual boundary marking. The fact that many wild equids deposit their fecal matter in one place and thus create piles of manure commonly referred to as "stud piles" is well known.

Shenkel (1947) concluded that scent marking legitimizes the leader, marks his territory and aids in making new acquaintances. Lyall-Watson (1964) interprets scent marking differently and states that scent marking aids the animal in maintaining familiarity with his environment and assures him that he is within his home range. This interpretation suggests that scent marking is not used as an aggressive display for territorial defense even though it remains effective in maintaining a territory.

The marking behavior of the non-territorial equids appears to have no obvious function (Klingel, 1972). Both Grevy's zebra (*E. grevyi*) and the wild ass (*E. africanus*) mark their territories with enormous piles of their own dung. Burchell's zebra (*E. burchelli boehmi*), a non-territorial species, marked only the feces of mares in estrous. Scent marking behavior in

this species may be vestigial and is probably inherited from territorial ancestors (Klingel, 1969). Moehlman (1974) observed dung piles of feral asses along trails, near water, and both within and on the boundaries of territories. All dung piles were used freely by all males.

Pawing. Originally, pawing behavior in equids served as part of their nutritive behavior and always occurred together with an olfactory investigation (Odberg, 1971). Feral asses paw to obtain food, to remove spines from cactus before eating and to reach plants protected by shrubs. They also occasionally paw and spread dung piles (Moehlman, 1974).

Several sources have reported that feral asses sometimes paw out large, deep holes in sand or gravel tanks or springs that have gone dry when searching for water. They also paw and sometimes destroy pipelines and cement tanks if water is not available (McKnight, 1958; Weaver, 1959). Domestic burros do not paw to break ice so they can drink, as do horses (Brookshier, 1974). There are no reports on whether they paw through snow to obtain grass as horses do.

Elimination. Horses stop whatever they are doing to urinate or defecate. They maintain a characteristic stance, according to sex, when eliminating. After elimination the stallion, but not the mare, smells the eliminative product (Hafez et al, 1969). Tyler (1972) reported that the New Forest ponies stopped grazing to urinate but merely raised their tails and continued to graze while defecating. Feist (1971) noted that the stallions' urination behavior is directed toward excrements of mares, whereas his defecation behavior is directed toward stud piles. Blakeslee (1974) found no evidence of dominance display in the eliminative behavior of appaloosa stallions.

Moehlman (1974) observed a wide range of response in male feral asses to their own urination, and to that of other asses. In over 80 percent of observations, males urinated and then walked away. They flehmened either while urinating or after smelling their own urine. Adult females made no response to urination but female foals and yearlings were observed urinating over an older female's urination spot.

Eliminative behavior. There is very little information available on the eliminative behavior of feral asses.

Moehlman (1974) reports on her observations. Feral asses, when defecating, stand with the tail raised at about a 45° angle from the hindquarters, the rear legs are spread and braced backward and the back is slightly concave. This posture would

indicate that they do not defecate while continuing to graze as do the New Forest ponies, which Tyler (1972) observed.

In one 24-hour period a male was observed defecating seven times. Social facilitation often increased defecation frequency, when one male would follow the other in defecating on a pile and then the first male would return and again defecate on the same pile. This repeat action by an individual appears to be evidence that the quantity of the eliminative product can be controlled. Defecation by one animal often incited other animals to defecate also. Males were sometimes stimulated by sniffing dung piles but on most occasions they sniffed the pile and then walked away. They also on occasion pawed and spread the pile after smelling. All males freely defecated on existing dung piles but this was never observed in females. The females of all age classes defecated and then walked away, unlike males who generally displayed an interest in their own and others' dung piles (Moehlman, 1974).

Predation and Disease

Predation. No scientific studies of predation on wild horses and burros have been done. The mountain lion (*Felis concolor*) is the only large predator remaining with the horse that is capable of killing an adult. It is possible that coyotes could kill unprotected foals. Feral dogs, when hunting in packs, certainly have the capability to attack and kill horses, but no such incidences have been reported.

The only natural enemies of horses are mountain lions and wolves. All horses fear bears but even in California, where grizzlies were once numerous, bears killed few horses. Wolves sometimes attacked horses but they preferred bison; after bison populations had been decimated they turned to cattle. The natural prey of the mountain lion is deer, but horses (especially foals) eventually became one of their favorite foods (Dobie, 1952).

Young and Goldman (1946) cite instances of mountain lions preying on horses in Arizona, Colorado and New Mexico. Raising colts and even maintaining a herd of adult horses was impossible in some areas due to lion predation. Mountain lions are also exceptionally fond of burro meat.

Diseases, pests and parasites. Outbreaks of diseases or infestations by pests and parasites within a wild animal population are often important indicators of other problems, related either to submarginal habitat, poor nutrition, overcrowding, competition, injury, harassment, or other factors.

The more common afflictions of domestic horses are listed here. It is possible that any one or more of them could be present in, or transmitted to, wild horse and burro herds. Symptoms, treatment and details are beyond the scope of this technical note.

Equine abortion: Causes may be grouped into four categories: those resulting from infection by Salmonella abortivoequina; those from streptococci infection which gains entrance through the genital tract; a virus of epizootic type which is highly contagious; and those abortions that occur from miscellaneous causes which cannot be classified into the above categories. These may vary from accidents or injuries to nutritional or endocrine disturbances.

Equine encephalomyelitis (sleeping sickness): a disease carried by 4 immunological, distinct, filtrable viruses. It is vectored by 13 members of 3 genera of mosquitos of which Culex tarsalis is the most likely carrier. It may also be carried by spotted fever ticks (Dermacentor venustus), and by assassin bugs (Triatoma spp).

Equine infectious anemia (swamp fever): a very serious blood disease of horses and mules. It is caused by a specific virus that may stay in the host for years. Treatment has been unsuccessful.

Infectious adenitis: Also referred to as strangles or distemper, the disease is caused by a bacterial streptococcus. Transmission is usually by the inhalation or ingestion of the infected discharges. It is highly contagious and the organisms may live outside the host's body for as long as six months.

Glanders or Farcy: A very old disease of bacterial origin. It may be diagnosed through the "mallein test." No cure is known.

Dourine: A chronic venereal disease of horses and asses commonly termed equine syphilis. It is caused by a protozoa and is spread mostly through mating, but may also be transmitted by biting insects.

In 1930 the Bureau of Animal Industry reported that 17% of the wild horses on the San Carlos Apache Indian lands were infected with dourine. Later tests indicated 80% of the horses in the high country were infected. The Federal Bureau of Animal Husbandry removed about 500 horses from Nevada herds in 1935 because of the presence of the disease (Wyman, 1945). The Bureau of Land Management in 1974 reported a suspected outbreak of the same disease in the N.W.C.

Rabies: Caused by a filtrable virus which usually occurs from injected saliva in a bite wound; an acute infectious disease of horses and all other warm-blooded animals, including man.

Anthrax: An acute infectious disease affecting horses, other warm-blooded animals and man. The bacillus of anthrax can survive in the soil for very long periods. It was the first disease in which immunization was accomplished with an attenuated culture by Pasteur in 1881.

Tetanus: Caused by an extremely powerful toxin liberated by the tetanus organisms (Clostridium tetanii). The organism is found in certain soils, horse dung, and sometimes in human excreta.

Parasites: The species and degree of harm vary in different parts of the world. They may be located in practically every tissue and cavity of the body. Some are specifically localized, others are migratory through different parts of the body.

The most important of these are: the bot flies (of which there are three species), the strongyles with six species (the larger of which are commonly referred to as bloodworms or redworms), the ascarids or roundworms, two species of pinworms, four species of stomach worms, the screw worm (largely confined to the South and Southwest), blowflies, ringworm, lice, mites, and ticks (Ensminger, 1951).

In addition, horses are susceptible to colds, laryngitis, bronchitis, pneumonia and pleurisy (Hanauer, 1973).

Competition

A great controversy has existed over competition between feral burros and other wildlife species. Certainly the most heated arguments for the elimination or drastic reduction of burros on public lands stem from the negative effects which burros are thought to have on desert bighorn sheep (Ovis canadensis nelsoni). Before the 1960's, almost all observers condemned burros as universally detrimental to bighorn sheep, accusing them of physically driving the bighorn from its habitat, destroying vegetation and compacting soil around watering areas, muddying waterholes and polluting them with feces and urine, and forcing the bighorn to abandon ancestral watering areas as a result of the behavioral incompatability of the two species (McKnight, 1957, 1958; Dixon and Sumner, 1939; Koehler, 1960; Ferry, 1955; Jaeger, 1950; Sumner, 1952; Dodge, 1951). Since the burro is

an introduced exotic, one can expect that it will thrive more or less at the expense of the native biota (McKnight, 1958); it cannot be considered a beneficial addition to any natural environment. Even so, evidence has accumulated to show that burros may not be the serious competitors with bighorn sheep they were once thought to be, at least not in every case. Basically, types of competition fall into three categories: feeding habits, watering habits, and social behavior.

Burros do compete with bighorn for food resources. Generally, where forage is ample, direct competition for food may not be serious; competition becomes most severe during the dry season and around watering sites (Jones, n.d.; Russo, 1973). The burro utilizes a wider range of food plants than does the bighorn and sometimes damages the range by pulling plants out by the roots and then consuming only a few mouthfuls (McKnight, 1958). But forage competition is decreased by the differential in preferred forage plants by the two species. Also, while burro and bighorn may feed in the same area, significant topographical barriers of relative ruggedness separate their respective sections of the foraging area (Welles and Welles, 1960). But dense burro populations can alter the makeup of a given geographical area by overgrazing, reducing its ability to support other herbivores (Jones, n.d.). McMichael (1964) concluded that sufficient overlap of food habits and summer range of burros and bighorn in the Black Mountains of Arizona to prevent the bighorn there from reaching their maximum population density. But in the River Mountains, Arizona, Denniston (1965) determined that forage was ample and that competition with the burro was not a serious factor in bighorn survival. Feral burros may deplete the bighorn's "emergency food supply" around watering areas, which bighorn use after traveling long distances to water through terrain where little or no forage exists (Welles and Welles, 1961).

In Death Valley, California, where the burro-bighorn controversy has been very heated for many years, Welles and Welles (1959, 1960, 1961) have conducted a great deal of research into the problems of competition for water resources between the two species. Based on wildlife water surveys done in 1959, and on feral burro studies carried out in 1960, they concluded that some of the most substantial bighorn populations in Death Valley fed and watered in the same areas as did burros. Other investigators contacted by the Welles' found little evidence of water hole fouling by burros other than by hoofprints in mud, but found evidence of both burro and bighorn sign throughout the Death Valley side of the Panamint Range (Welles and Welles, 1961; Jones, n.d.). In 1937, when a park ranger discovered a spring utilized by both burros and bighorn sheep in the Panamint Mountains, he predicted that the burro would eliminate bighorn

from the spring. But both species were still using this spring "simultaneously and without strife" when it was next investigated in 1960 (Welles and Welles, 1961, p. 178). Jones (n.d.) has also observed that in some areas burros and bighorn drink at the same spring without conflict. The nocturnal watering habits of the burro also tend to lessen direct competition with the diurnal bighorn (Welles and Welles, 1960). Neither do burros foul water sources as often as was once believed (Welles and Welles, 1960). Jones (n.d.) found springs polluted with bighorn pellets, evidence that burros are not the only animals guilty of fouling water sources. Investigators who participated in a 1955 bighorn sheep census in Death Valley National Park concurred that while the burro may be bad for vegetation, watershed and wildlife in general, no specific criteria existed to specifically document a negative impact on bighorn by burros in the Park (Welles and Welles, 1962; Jones, (n.d.).

While feral burros are reputed to dominate bighorn sheep and physically drive them away from watering areas, published observations do not bear this out. Weaver (1959) observed a small band of bighorn at a water hole when a burro jack came in to drink. The bighorn drifted away, but there was no animosity displayed. While the original band of sheep did not return, others arrived. A ram and ewe bighorn approached a band of nine burros in the Black Mountain foothills, Arizona. When the burros moved toward the bighorn, the sheep maintained a distance of about 10 yards for 20 minutes, then moved rapidly away. The bighorn seemed nervous around the burros, but no outward signs of aggression existed (McMichael, 1964). Welles and Welles (1960) observed 13 bighorn pass quietly between two groups of burros in Trail Canyon, Death Valley National Park. And a prospector in Death Valley reported seeing a bighorn ram rush at and ram a burro at a spring. The burro left at a fast lope and continued for quite a distance (Sumner, 1959).

Some recent studies recording burro-bighorn competition in specific geographic areas include Weaver (1972), Weaver, Mensch and Thomas (1969), Weaver and Mensch (1969, 1970), Weaver and Hall (1971), Sanchez (1974), Wauer (1974), Farrell (1973) and McMichael (1964).

Competition with other large herbivores, including mule deer (Odocoileus hemionus) and pronghorn (Antilocarpa americana) is a minor problem. Burros share the range with pronghorn in portions of Nevada, Arizona, New Mexico, Oregon and Wyoming, but the typical habitat used by each species is usually different. Competition is also minimal between mule deer and burros in most cases (McKnight, 1958). Wauer (1964) reported that in Bandelier National Monument, New Mexico, the ranges of mule deer and burros did not overlap, but he was unable to explain this phenomenon.

The following section was contributed by Milton Frei, Bureau of Land Management, Denver Service Center. It was written mainly to apply to the wild horse, but the concepts apply to wild burros as well. Since no management research for the burro appears in the literature, this section on the horse has been included in this report.

Wild Horse Management

Population management. The management of wild horses presents a new challenge to public land administration agencies such as the Bureau of Land Management and the U. S. Forest Service. Heretofore management responsibilities of these agencies have been limited to animal habitat rather than the animals themselves.

Although the concept of wild horse population management is a relatively new one, the principles of animal population management are well documented and can be applied directly to wild horses.

The first step in managing wild horse populations is to determine the number of animals to manage in any particular area. The determination of this number must be based on available habitat and consideration of other animal species or resource values.

Once the number of wild horses to be retained for management has been determined, the next step is to analyze those factors which have molded the population into what it is today. It must be true that over the long run, as many wild horses die as are born. This is the same scheme that nature has built into all of her animal species. Therefore, before management of wild horse populations can begin, the factors of population dynamics (productivity, mortality, sex ratio and age structure) must be collected and understood. These factors can then be analyzed to determine the forces which have shaped the population and to predict the numerical abundance of wild horses in the future.

The first step in a wild horse population analysis is to determine if the population is stable, increasing or decreasing. The following formula represents one method for determining the stability of a wild horse population:

A = Estimated number of adults in population (1 year & older)
B = Foal/100 adults (percent)
F = Number of foals
Zf = Mortality of foals (percent)
Nf = Mortality of foals (number)
Za = Mortality of adults (percent)
Na = Mortality of adults (number)
Y = Total population estimate (adults and foals)
P = Projected population
I = Population increase or decrease

$$(A)\ (B) = F$$
$$(F)\ (Zf) = Nf$$
$$(A)\ (Za) = Na$$

$$A + F = Y$$
$$Y - (Nf + Na) = P$$
$$P - A = I$$ (increase or decrease) If P is less than A, reverse P and A in formula. Values will then be decrease in population.

$$\frac{I}{P} = \text{Population increase where } P > A$$

$$\frac{I}{A} = \text{Population decrease where } P < A$$

Once the stability of a wild horse population has been determined, it is necessary to analyze other population data prior to actual manipulation of the population. For example, if the population is determined to be increasing in total numbers and it is desirable to decrease total numbers, an analysis can be made as to the ratio of male animals to female animals in the total population. It may be possible to decrease the productivity of wild horses by increasing the number of male animals in relation to the number of female animals.

In another example, if the population is determined to be stable, it is important to understand the reasons why. It may be that births are equalling deaths or that the population is on the brink of disaster. In this example, an analysis can be made as to the age structure of the population. If the age structure is balanced (i.e. all age classes adequately represented), nothing more in the way of management need be done. However, if one or more age classes are lacking or totally missing, it may indicate that the missing age classes must be restored if the population is to survive.

Population control. Control of wild horse populations differs from control of big game populations in that they are not a huntable or game species. Shooting of wild horses by persons other than officials of the Bureau of Land Management or U. S. Forest Service is prohibited by federal law and is socially unacceptable.

Control of wild horses is also restricted in that it is a violation of federal law to use aircraft or motorized vehicles to capture or kill a wild horse. As a result, the only techniques available to capture the animals alive involve time consuming techniques such as water trapping, dry trapping, roping and immobilizing. This is complicated by the fact that many areas are too rough or have too many water sources for these techniques to be effective.

Disposing of wild horses which have been captured presents additional complications in population control. If animals are destroyed the problem arises as to what should be done with their carcasses. It is against federal law to convert the remains of wild horses into commercial use. If live animals are given away to private individuals for keeping under humane conditions, the problem arises as to transfer of title to the animal. It is not possible to transfer title to wild horses and as a result, many individuals are reluctant to keep a wild horse under those conditions. In addition, wild horses are just as their name suggests, "wild." Full-grown horses are very powerful animals and can be extremely dangerous when placed in the hands of inexperienced individuals.

Research Needs

All aspects of wild horse ecology need research, therefore it is difficult to assign priorities. However, if management of wild horses is to be meaningful to the land managers in the near future, it would appear that knowledge of year-round habitat requirements would be high on the list of research needs. Also desperately needed are data on population dynamics and competition with other animals.

Wild Horse Management Plans

Both the U. S. Forest Service and the Bureau of Land Management have developed plans for protection, management and control of wild horses. Both agencies have land use planning systems that evaluate the resource and then develop integrated planning and management for all the multiple uses of the land area under consideration. These include the vegetative and watershed conditions, wildlife needs, livestock use, recreational use, and other legitimate demands.

Legislation Concerning Wild Horses and Burros

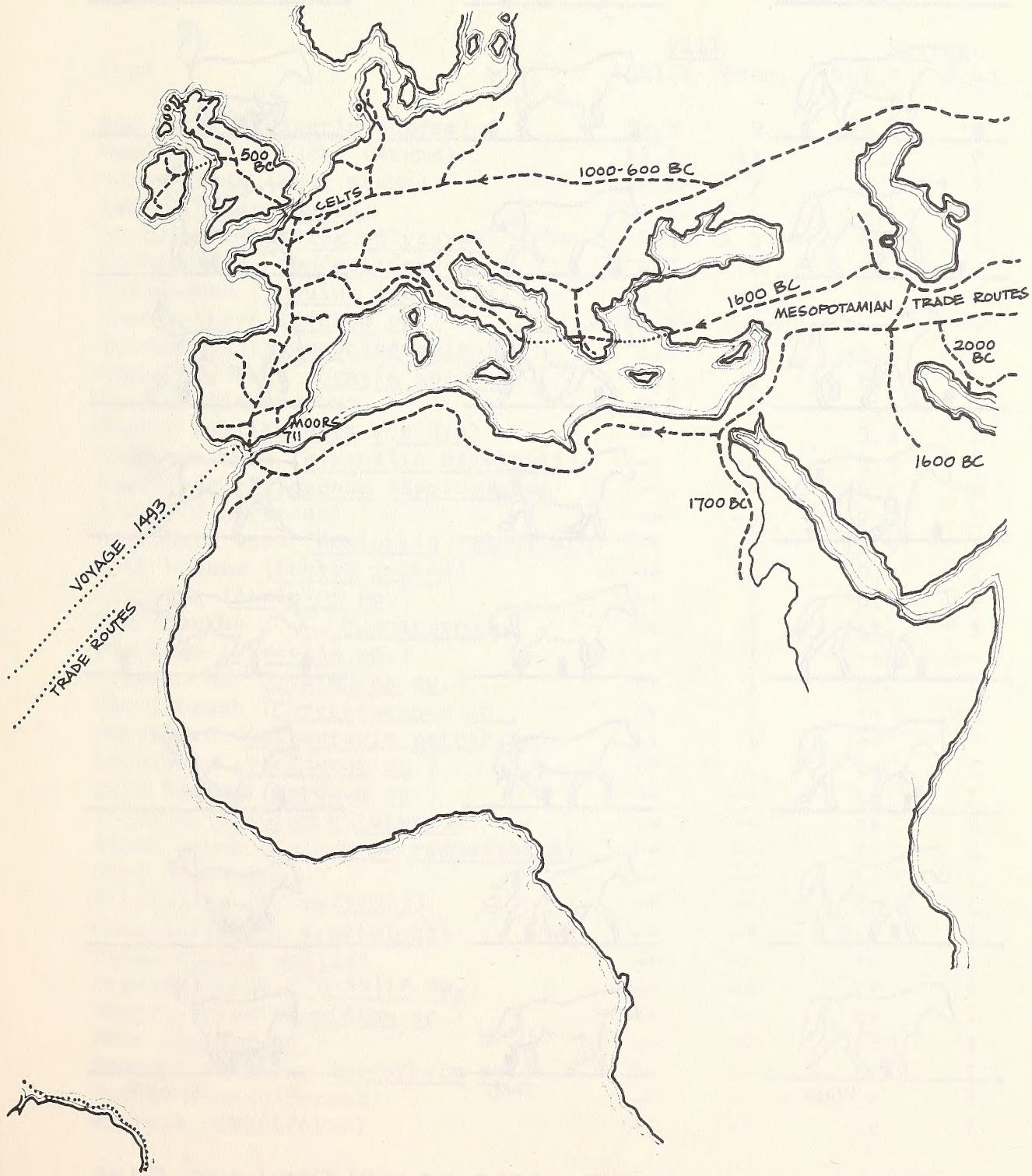
Congress has passed two Federal laws to protect wild horses. Public Law 86-234, passed in 1959, makes it illegal to use aircraft or motorized vehicles to capture or kill wild horses. Public Law 92-195, passed in 1971, places wild horses and burros roaming on national resource lands under the jurisdiction of the Secretaries of the Interior and of Agriculture for protection, management and control. It provides a penalty for harassing, capturing, killing, or selling wild horses, and prohibits the processing of wild horses into any commercial product. The maximum penalty is a fine of $2,000 and imprisonment for one year. This Act also provided for the establishment of an advisory board to make recommendations on the management and protection of wild horses and burros.

Under the laws of the various states, wild horses are not recognized as game animals or wildlife. They are considered as "estrays" or abandoned animals and are not included under the provisions of the Taylor Grazing Act.

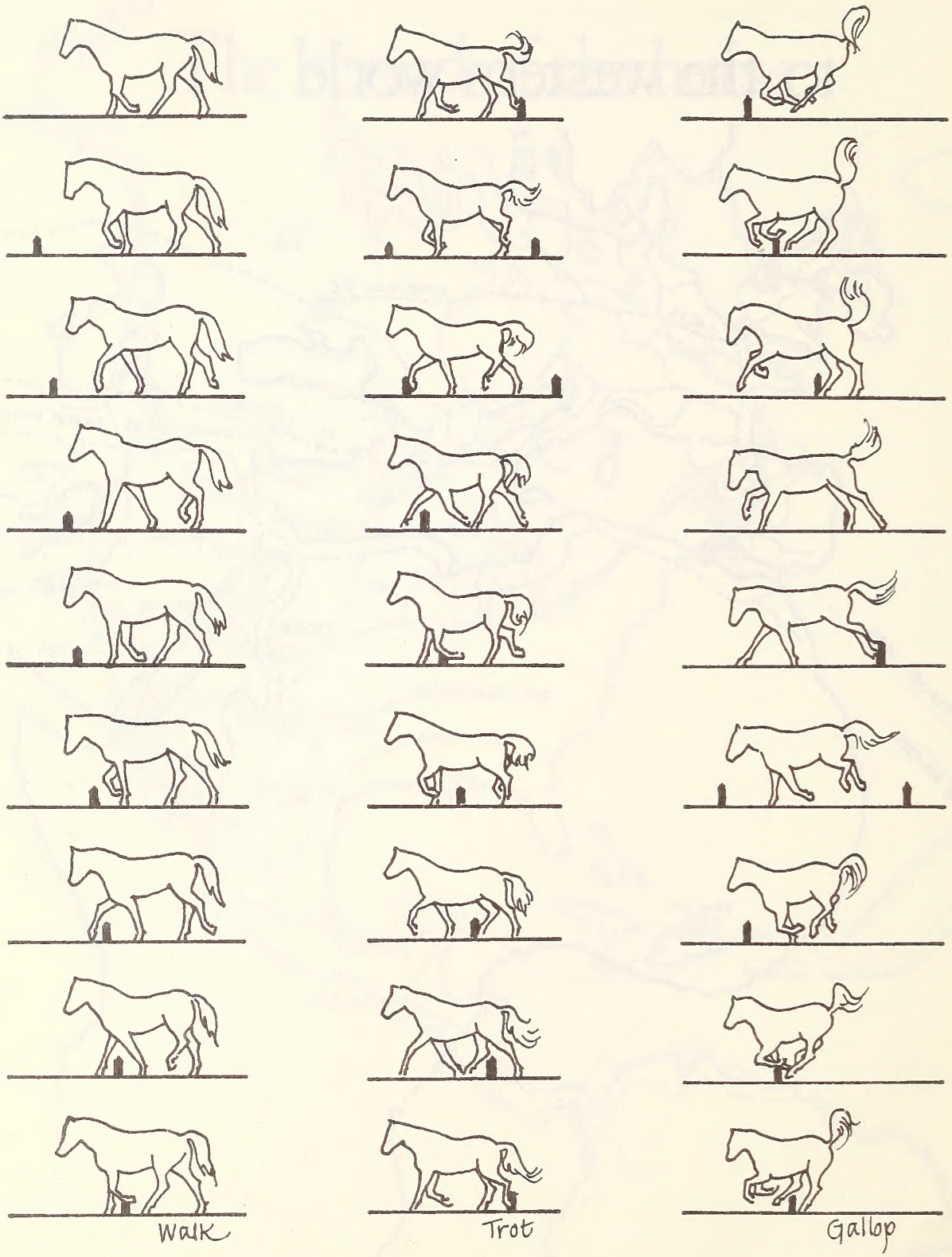
Cooperative agreements for the protection and management of wild horses and burros are authorized between the Secretaries of the Interior or Agriculture and state and local government agencies and with other landowners.

APPENDIX 1
The Spread of the Horse to the Western World
Adapted from Smith, 1969

to the western world



APPENDIX 2
Movement on Land
Adapted from Tricker and Tricker, 1966



THREE GAITS OF THE HORSE, DRAWN FROM CINÉ FILM

APPENDIX 3

Food Items Eaten by 19 Feral Burros Collected From the Death Valley National Monument, 1959. (Information from California Department of Fish and Game).

Item	Fall Vol.%	Fall Freq.	Spring Vol.%	Spring Freq.
Bur sage (Franseria dumosa)	52.5	9	13.3	6
Unidentified forbs (stems)	13.5	11	49.4	9
Grass stems (leaf stems)	10.0	7	7.8	4
Aster (Aster abatus)	4.5	6	1.1	1
Atriplex (Atriplex polycarpa)	4.5	3	tr	1
Atriplex (A. confertifolia)	4.0	4	--	--
Cottonwood (Populus fremontii)	4.0	6	--	--
Desert thorn (Lycium sp.)	3.5	3	--	--
Burrobrush (Hymenoclea salsola)	1.5	1	1.7	2
Spiny hop-sage (Grayia Spinosa)	1.5	1	tr	1
Unidentified browse	0.5	2	--	--
Mormon tea (Ephedra viridis)	--	--	3.3	1
Wishbone bush (Mirabilis bigelovii)	--	--	0.6	1
Buckwheat (Erlogonum fasciculatum)	--	--	4.4	6
Sedge (Cyperaceae)	--	--	2.2	1
Buckthorn weed (Amsinckla tessellata)	--	--	15.0	3
Rush bebbea (Bebbia juncea)	--	--	0.6	2
Atriplex (Atriplex sp.)	tr	2	0.6	3
Chorizanthe (C. brevicornu)	tr	4	tr	3
Phacella (Phacella sp.)	tr	1	--	--
Cryptantha (Cryptantha sp.)	tr	1	tr	2
Rabbitbrush (Chrysothamnus sp.)	tr	1	--	--
Matchweed (Gutierrezia sarothrae)	tr	1	--	--
Penstemon (Penstemon sp.)	tr	2	tr	1
Wild barley (Hordeum sp.)	--	--	tr	1
Filaree (Erodium cicutarium)	--	--	tr	2
Black brush (Coleogyne ramosissima)	--	--	tr	1
Mint (Labiatae)	--	--	tr	1
Brickellia (B. watsonii)	--	--	tr	1
Chaenactis (C. stevioides)	--	--	tr	1
Dalea (Dalea mollis)	--	--	tr	1
Ground-cherry (Physalis sp.)	--	--	tr	1
Pepper-grass (Lepidium sp.)	--	--	tr	1
Mint (Saliva sp.)	--	--	tr	1
Evening primrose (Oenothera sp.)	--	--	tr	1
Borage (Boraginaceae)	--	--	tr	1
Mustard (Cruciferae)	--	--	tr	1

APPENDIX 4

Food Items Eaten by 20 (Burros) China Lake - April, 1966. (Information from California Department of Fish and Game).

Item	Vol.%	Freq.
	20	
BROWSE:		
Spiny hop-sage sd. (*Grayla spinosa*)	trace	3
Fourwing saltbush sd. (*Atriplex canescens*)		1
Creosoate bush lf. (*Larrea divaricata*)		1
Nevada ephedra st. (*Ephedra nevadensis*)		2
Unld. browse st.		4
Wishbone bush (*mirabills bigelovii*)	1.0	11
Burrobush (*Hymencolea salsola*)	trace	8
Browse subtotal	1.0	
FORBS:		
Unid. forbs (st, lf)	86.0	20
Buck thorn weed lf, hd, sd (*Amsincklatessellata*)	11.0	19
Unid. compositae (hds)	1.0	10
Phacella pods & sd. (*Phacella sp.*)	trace	6
Gilla sd & st (Gilla sp.)		16
Fremont's chaenactis (*Chaenactis fremontil*)		15
Red-stem filaree (*Erodium cicutarium*)		15
Stickleaf pods & sds (*Mentzelia sp.*)		11
Pepper-grass pods (*Lepidium nitidum*)		5
Poppy sd. (*Eschscholtzia sp.*)		5
California mustard (*Thelypodium laslophyllum*)		3
Fringe-pod pods (*Thysanocarpus sp.*)		4
Buckwheat lf (*Erlogonum sp.*)		3
Snake's head bracts & sd (*Malacothrix coulteri*)		2
Wing-nut cryptantha sd (*Cyptantha pterocarya*)		2
Coreopsis sd (*Coreopsis sp.*)		1
California coreopsis sd (*Coreopsis californica*)		1
Loco weed pod & sd (*Astragalus sp.*)		1
Hog-fennel sd (*Lomatium sp.*)		1
Forb subtotal	98.0	
GRASS:		
Grass lf & st. (Gramineae)	1.0	13
Cheatgrass sd. (*Bromus tectorum*)	trace	2
Bentgrass spike (*Agrostis sp.*)		1
Grass subtotal	1.0	

APPENDIX 5

Tentative Flora of the Trampas Wash Area

Species	Family	Common Name
Ephedra sp.	Gnetaceae	
Hespero callis undulata	Liliaceae	Desert lily
Yucca sp.	"	
Agave sp.	Amaryllidaceae	
Eriogonum inflatum	Polygonaceae	Desert trumpet
Eriogonum sp.	"	
Eriogonum sp	"	
Eriogonum sp.	"	
Chorizanthe rigida	"	Rigid Spiny-herb
Mirabilis aspera	Nyctaginaceae	
Calandrinia ambigua	Portulacaceae	
*Eschscholtzia glyptosperma		
*Cercidium floridum	Leguminoseae	Palo verde
Cercidium microphyllum	"	Palo verde
*Prosopis juliflora	"	Honey mesquite
Prosopis pubescens	"	Screwbean mesquite
[1]Acacia greggii	"	Catclaw
Cassia armata	"	Desert senna
Dalea fremontii	"	Fremont's dalea
Dalea mollis	"	Silk dalea
*Krameria grayi	"	White ratany
Euphorbia setiloba	Euphorbaceae	
Fagonia californica	Zygophyllaceae	
[2]Larrea divaricata	"	Creosote bush
*Fouquieria splendens	Fouqueiriaceae	Ocotillo
Tamarix pentandra	Tamaricaceae	Salt cedar
Petalonyx thurberi	Loasaceae	Sandpaper plant
Eucnide urens	"	Rock nettle
Mentzelia tricuspis	"	
Opuntia biglovii	Cactaceae	Teddy bear cholla
*Opuntia sp.	"	Cholla
O. basilaris	"	Beavertail
Echinocereus engelmannii	"	Hedgehog cactus
*Oenethera brevipes	Onagraceae	Yellow cups
*O. refracta	"	Bottle washer
Asclepis sublata	Asclepidaceae	Desert milkweed
Langloisia sp.	Polemoniaceae	
Phacelia sp.	Hydrophyllaceae	
Pectocarya sp.	Boragnaceae	Comb-bur
Amsinkia sp.	"	Forget-me-not
Cryptantha sp.	"	
Hyptis emoryi	Labiatae	Desert lavender
Salazaria mexicana	"	Paperbag bush; Bladder sage

Tentative Flora of the Trampas Wash Area (Cont'd)

Species	Family	Common Name
*Lycium andersonii	Salonaceae	
Physalia crassifolia	"	Desert cherry
Nicotinia trigoniphylla	"	Desert tobacco
Mimulus sp.	Scrophulariaceae	
Mohavea confertifolia	"	Ghost flower
Chilopsis linearis	Bignoniaceae	Desert willow
*Plantago sp.	Plantaginaceae	Plantain
Baocharis glutinosa	Compositae	Seep willow
3*Pluchea sericea	"	Arrowweed
*Ambrosia dumosa	"	Burrobush
Hymenoclea salsola	"	Burroweed
Encelia sp.	"	Brittlebush
*Geraea sp.	"	
3*Bebbia juncea	"	
*Chaenictus sp.	"	Pincushion
Peucephyllum schottii	"	Desert fir
Atrichoseris platyphylla	"	
Psathyrotes ramosissima	"	Velvet rosette
*Rafinesquia sp.	"	Desert chicory
Porophyllum gracile	"	Odora

* Burros have been observed eating this species

1 Burros are known to forage on this species elsewhere and presumably they do here also

2 Colt has been seen nibbling on creosotebush

3 Flowerheads eaten

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DISTRIBUTION OF WILD BURROS IN THE WESTERN UNITED STATES

Appendix 6

Burley
Pinedale
Lander
Casper
Redding
Ukiah
Susanville
Winnemucca
Elko
Battle Mt.
Rawlins
Rock Springs
Salt Lake
Carson City
Folsom
Vernal
Craig
Ely
Price
Fillmore
Richfield
Grand Junction
Glenwood Springs
Montrose
Cedar City
St. George
Kanab
Monticello
Canon City
Las Vegas
Bakersfield
Riverside
Albuquerque
Socorro
Phoenix
Yuma
Safford
Roswell
Las Cruces
Wild Burro Area
Forest Service Lands
BLM Lands Best consolidated public ownership
BLM Lands Scattered public ownership
Other Federal Lands Parks, Game Ranges, Recreation Areas, and Major Military Reservations*
*Remaining federal areas and state lands not shown